AIR FORCE JOURNAL of LOGISTICS

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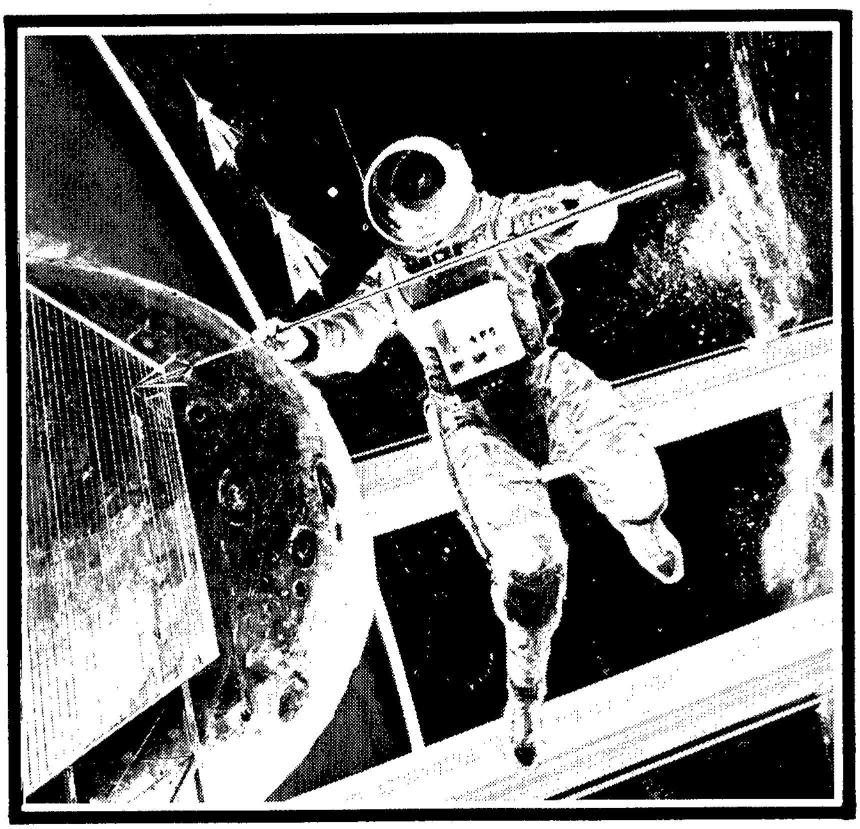

Special Section:

The Challenge of Space Logistics

- *Munitions Production Base*
- *The Logistics Warrior*
- *Pacific Theatre Logistics—WWII*
- *Mission Support Kits*
- *User-Developed Software*

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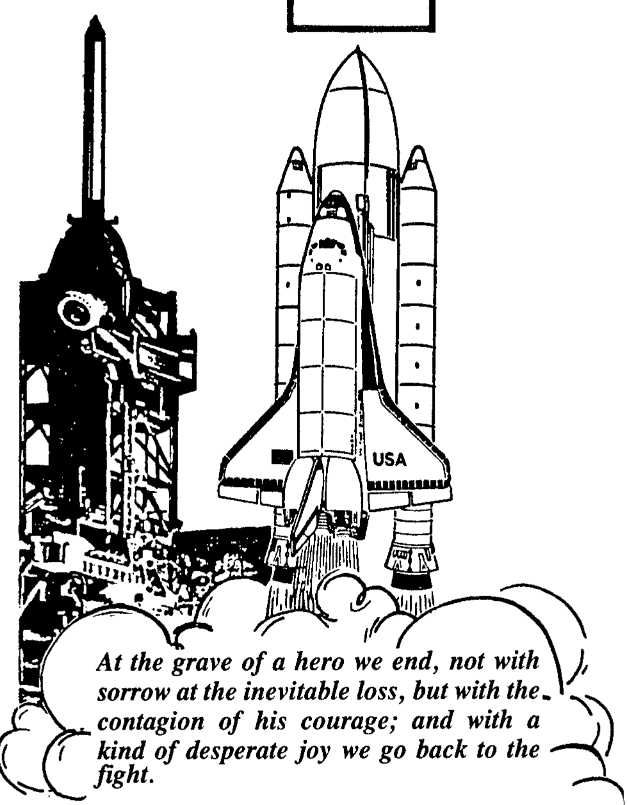

At the grave of a hero we end, not with sorrow at the inevitable loss, but with the contagion of his courage; and with a kind of desperate joy we go back to the fight.

Oliver Wendell Holmes, Jr.
1841–1935

Purpose The *Air Force Journal of Logistics* is a non-directive quarterly periodical published in accordance with AFR 5-1 to provide an open forum for presentation of research, ideas, issues, and information of concern to professional Air Force logisticians and other interested personnel. Views expressed in the articles are those of the author and do not necessarily represent the established policy of the Department of Defense, the Department of the Air Force, the Air Force Logistics Management Center, or the organization where the author works.

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The Pacific Theater in World War II: Challenges to Air Logistics

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To an extent never before contemplated in military enterprise, the global nature of World War II demanded forces that could cover vast distances rapidly and apply firepower to constantly shifting lines of battle and target priorities. These needs made the expansion of airpower's role in warfare inevitable because then, as now, airpower's unique value lay in its ability to combine three key characteristics—speed, range, and flexibility.

> ***"The crushing burden of logistics occupied the time of many commander and eventually led to major changes in operational strategy and tactics."***

Yet, these qualities were brought to fruition with far less ease than we often recognize. The air arm's *speed* and *range* led to its employment in unprepared and inhospitable areas, demanding severe adaptation from a fledgling air logistics corps. And each inch of mission *flexibility* attributed to airpower had to be forcefully wrenched from a quickly conceived, often dry, support pipeline. The phrase "we'll wing it" could well have been coined to describe the logistical support of US airpower in the China-Burma-India (Far Eastern) and Pacific theaters. The crushing burden of logistics occupied the time of many commanders and eventually led to major changes in operational strategy and tactics.

Pipeline to the Far East

The Far East was still a European, mostly British, colony at the start of the war. Unlike the European theater, in which a commercial and military logistics infrastructure already existed, the eastern colonies had developed along a predominately agrarian model. A system of highways and railroads had not been developed, so most transport was by barge or coastal freighter. By 1939, the Japanese held all the major ports and water lines of communication. Before their advance had been halted in the Fall of 1943, they had pushed all the way to the border of India. The major ports of Saigon, Singapore, Bangkok, and Rangoon, as well as the major rivers, Nakhon Chai Si, Salween, and most of the Irrawaddy, were in Japanese hands. Most important were Bangkok and Rangoon, both located at the termini of major rail and water lines of communication.

The famous Burma Road fell in the Spring of 1942. From then on US support of allies in China depended solely on air supply. The first flight over the "Hump" from the Assam valley to western China was on 8 April 1942. (3:60)

Before details of the "Hump" mission and operations of the XX Bomber Command in China are discussed, the global position of the theater of battle should be examined. A quick glimpse at a globe reveals an operational theater over 10,000 miles from the US. The primary means of supply from the US to India was by ship, from either the East or West coast. Shipping time from Los Angeles to Bombay averaged over two weeks; from Newport News to Bombay it exceeded a month. (1:75) From Bombay to the jump-off point for the "Hump" was nearly 1,500 air miles—considerably more via narrow gauge railroad or barge.

Support of air operations was virtually impossible with such extended supply lines, so for high priority items, such as R-3350 engines for the B-29, Air Transport Command flew a ferry service direct from the States. Pilots would change at every stop, but the plane would continue on to the final destination. By 1944, using the air route, planes could deliver parts from stateside to Calcutta in under 70 hours, an air distance of some 11,000 miles. (1:78)

The primary purpose of the "Hump" airlift was to demonstrate enough military capability to keep China in the war as a possible base for attack on the home islands of Japan. (3:58) At this time, Japan already occupied much of China, and the Chinese accordingly had seen fit to put their Civil War on hold until the Japanese were evicted. Every item needed by the American forces in China had to be airlifted over the "Hump." This mission grew from a humble beginning in 1942, when it airlifted about 300 tons/month, to its peak of over 70,000 tons in July 1945.

> ***"It was a route well marked by the aluminum graves of those aircraft and crews that did not make it."***

While 70,000 tons seems small today, it was a significant achievement from a 1945 perspective. Three primary cargo aircraft were then in use—the C-47, C-46, and C-54. Their payloads ranged from 2.5 to 4 to 6 tons, respectively, on these missions. (3:62; 128) The C-54 was a late entry and was the only four-engine craft. This was an important feature when flying the route over the "Hump," which stretched for 550 miles over jungle and 20,000-foot mountains. Loss of an engine on a two-engine aircraft spelled doom for the ship and usually the crew. It was a route well marked by the aluminum graves of those aircraft and crews that did not make it.

Supporting the Bombing Campaign

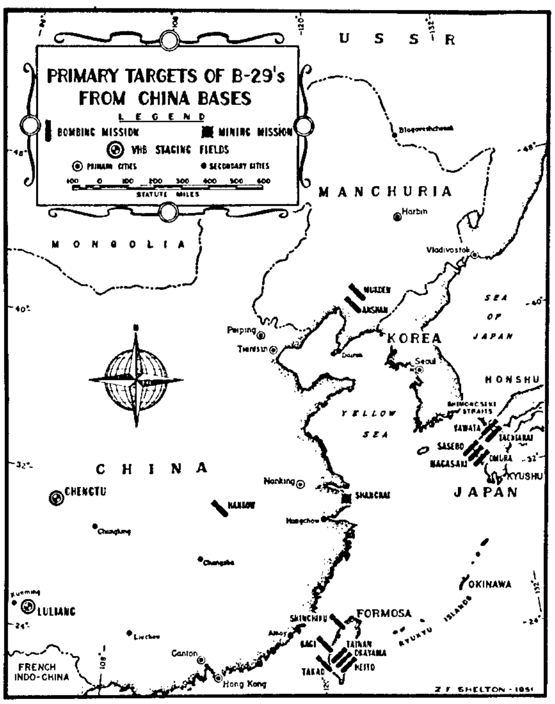
While the "Hump" airlift may be the most famous of the Far Eastern air operations, it was not the most militarily

critical, being solely for support of a Chinese holding operation that awaited conclusion of the European campaign. Strategic bombing, well taught in Europe, was about to be applied against the Japanese from the bomb bays of the B-29 Superfortress. The Twentieth Air Force was formed for this purpose and, after much political maneuvering, was permitted to report directly to the Air Corps Commander, General Arnold, who was a member of the Joint Chiefs of Staff. General Arnold convinced his colleagues that the unique mission and characteristics of the B-29 required the unit to report to him rather than to a theater commander as would normally be the case. (1:35) The range of the Superforts allowed them to roam over the Pacific theaters commanded by Generals Stilwell and MacArthur, and Admiral Nimitz. To preclude continual changes in mission and priorities, operational command was retained in Washington.

However, logistics and administrative support was provided by the *theater* commander, an arrangement which proved more satisfactory than might be expected, but ultimately depended on a good deal of "self-help" support.

Hand-Built Airstrips

The XX Bomber Command was tasked to attack Japan from China under the operational code name "Matterhorn." In mid-1943 the Chengtu area was selected as the base for B-29 operations. Chengtu's greater security resulted in it being chosen over the more strategically located Kweilin preferred by General Chennault. (1:65) This proved to be a correct decision, as Kweilin fell to the Japanese in late 1944, only shortly after the XX Bomber Command began operations out of Chengtu.



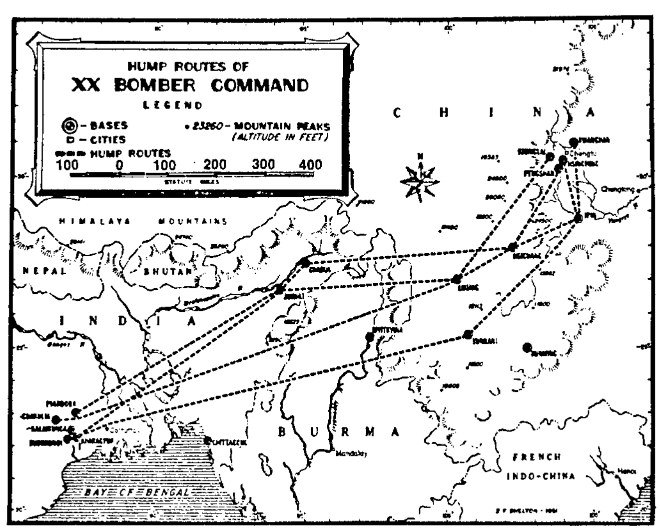
Flat, with good weather, Chengtu was well suited for bomber operations. Unfortunately, it lacked the finer luxury of *airfields*. Constructing four heavy bomber bases would be a difficult task even in the States, but in China the job was enormously problematical. For one thing, there was no heavy equipment available. Instead, over 300,000 Chinese were drafted as laborers from villages within a 150-mile radius of the area. (1:68) By May 1944, four 8,500-foot bomber strips had been completed. Each strip was about 19 inches thick and was equipped with 52 hardstands, all "hand-built." Stones

Building the Chengtu Airfields

were carried from local streambeds; crushed with hammers; combined with sand, clay, and water; carried in baskets on shoulder yokes or in wheelbarrows; and then rolled in place by hand-drawn rollers. The payroll for this construction was so large that Chinese currency had to be imported, using valuable cargo space on none other than the already over-burdened "Hump" airlifters. (1:70; 71)

Operation Matterhorn

With airfields finally complete, operations could begin. Recall, though, that everything needed by US forces in China had to be flown in via the "Hump" pipeline; supplies for the XX Bomber Command—avgas, oil, bombs, parts, and food—were no exception. The basic premise of Matterhorn, due somewhat to the shortage of organic airlift but mainly to the Army Air Force (AAF) concept of the bomber unit as a self-contained unit, was that it would be *self-supporting*. This meant B-29s would be used as transports. Some B-29s were



stripped of virtually all armament and used as aerial tank cars. (1:87) Without question, aviation gasoline was the real "long pole" in the Matterhorn tent. It took 7 round trips of 11 hours each to ferry in enough avgas for *one mission* against Japan. (2:325)

"A big B-29 was just the thing to shear a clinging demon from a laborer's back."

As if these obstacles were not enough to overcome, the Chinese workers presented another—accidents. The local Chinese held a superstition that they were closely pursued by demons. If one could shake his demon, his life would improve immensely. A big B-29 was just the thing to shear a clinging demon from a laborer's back. The workers would hide along the runways waiting for departing or landing Superfortresses. When one was sighted, they would run in front of the propellers hoping their demons would be struck. Obviously, sometimes it was the Chinese that were hit by the props. While the other Chinese watching would laugh hysterically at such great fun, reporting these occurrences to headquarters demanded a great deal of paperwork. (2:334) To ease the administrative burden, such accidents eventually ceased to be reported.

Evolving Maintenance Concepts

Despite the problems, the first Matterhorn mission put up 98 bombers, a feat the Eighth Air Force had taken 14 missions to accomplish in Europe. (1:93) Further efforts to increase the support of B-29 forces initiated wide-ranging changes in maintenance concepts and organizations which continued to evolve throughout the war. These new concepts were very significant to the development of today's Air Force and warrant further discussion.

In the "traditional" air organization employed in the European theater, maintenance responsibility was divided into four echelons. Army Air Force Regulation 65-1 defined these levels:

> *First echelon maintenance* will normally consist of servicing airplanes and airplane equipment, preflight and daily inspections, and minor repairs, adjustments, and replacements. All essential tools and equipment must be transportable by air.
>
> *Second echelon maintenance* will normally consist of servicing airplanes and airplane equipment, performance of the periodic preventative inspections and such adjustments, repairs, and replacements as may be accomplished by the use of hand tools and mobile equipment authorized by Tables of Basic Allowances for issue to the combat unit. This includes engine change when the organization concerned is at the location where the change is required. Most of the tools and equipment for 2d echelon can be transported by air; but certain items, such as transportation, radio, etc., necessitate ground means of transportation.
>
> *Third echelon maintenance* embraces repairs and replacements requiring mobile machinery and other equipment of such weight and bulk that ground means of transport is necessary. Units charged with this echelon of maintenance require specialized mechanics. This echelon includes field repairs and salvage, removal and replacement of major unit assemblies, fabrication of minor parts, and minor repairs to aircraft structures and equipment. Normally, this echelon embraces repairs which can be completed within a limited time period, this period to be determined by the situation prevailing.
>
> *Fourth echelon maintenance* includes all operations necessary to completely restore worn or damaged aircraft to a condition of tactical serviceability and the periodic major overhaul of engines, unit assemblies, accessories, and auxiliary equipment; the fabrication of such parts as may be required in an emergency or as directed in technical instructions; the accomplishment of technical compliance changes as directed; replacement, repair, and service checking of auxiliary equipment; and the recovery, reclamation, or repair and return to service of aircraft incapable of flight.

Echelons one and two were performed by the using organizations, echelon three by Air Service Command's (ASC) theater-based sub-depots, and echelon four by ASC's main depots. Note that the organizational level maintenance resources were owned by the squadrons, but the sub-depots which performed mostly what we today refer to as *field* or *intermediate* level work, reported to the Air Service Command, *not* the local combat commander (Figure 1).

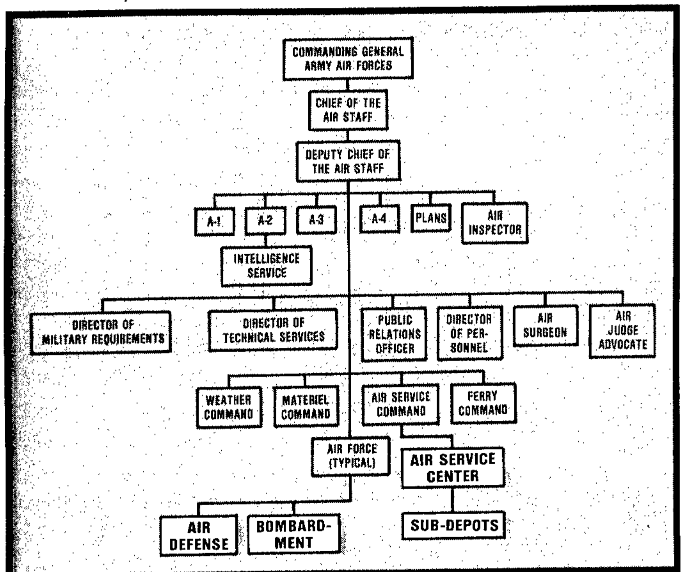


Figure 1: AAF Organization Highlighting Levels of Maintenance.

In the European theater, this factor resulted in two common problems. First, depending on squadron taskings, one squadron may have been working its maintenance personnel around the clock while its sister squadron counterparts within the same bomb group were playing basketball. Second, there were frequent complaints that the ASC's sub-depots were unresponsive to mission requirements and the bomber commander had no control over the problem. (4:17)

In June 1944, General Arnold directed the XX Bomber Command to control third echelon maintenance and the supporting service groups. (1:121) The maintenance personnel from the service groups and bombardment squadrons were grouped and some economies of scale were realized. This organizational structure would carry over when the newly constituted XXI Bomber Command moved into the Marianas. In essence, it remains the mainstay of strategic bomber maintenance doctrine today.

Move to the Marianas

It was soon realized that missions from China were relatively ineffective considering the massive logistical inputs necessary. At the same time, island bases were being prepared in the South Pacific for attacks against the home islands of Japan. The preparation of air bases in the Marianas, some 5,000 miles from the US, was fraught with its own logistical problems. Not least among these was the fact that there was no

single manager for either construction or operations. The Navy was responsible for shipping, construction, and airdrome maintenance; the Army for supplies, clothing, general equipment; and the Army Air Force for air technical supplies. (1:537)

> ***"General Spaatz confirmed that these [maintenance] changes had contributed to the 'unparalleled operational accomplishments of the Twentieth Air Force.'"***

Regardless, the XXI Bomber Command began operations against Japan with fewer support problems than in China. Maintenance support improved with the new organizational arrangement. All supply and maintenance activities were centralized under Colonel Clarence S. Irvine, the Deputy Chief of Staff for Supply and Maintenance, from November 1944 to the end of the war. (1:544) A supply controller and a maintenance controller were in charge of all activities in their areas. Service center personnel were grouped with maintenance personnel in functionally aligned shops, with the responsibility of supporting all assigned aircraft. In the shops, production line methods were used and the work force could respond to the different requirements in the groups with maximum effectiveness. (1:544) Although there was considerable resistance from various units, General LeMay gave strong support and squelched opposition. In 1945, General Spaatz confirmed that these changes had contributed to the "unparalleled operational accomplishments of the Twentieth Air Force." (1:545)

B-29 Maintenance at Guam: R-3350 Engines

Operating from the Marianas - Isley Field, Saipan

Night Work During the Fire Blitz

With the supply of operable aircraft assured, the Twentieth Air Force was able to mount steady attacks against Japan. The intensity of these attacks, and a change in tactics, resulted in still another logistical problem. The original plan had been to use high-explosive bombs as had been used in Europe. Because of a variety of factors, one being the highly flammable buildings in Japan, tactics were changed to replace high explosives with incendiaries. A concurrent change to tactics was made primarily for logistical reasons—the marginally effective high altitude attacks were brought down to low level where greater precision could be achieved. The driving force for this adjustment was the B-29's unfortunate reputation as an engine eater. It would swallow a valve and catch fire with great regularity. In an effort to ease the strain on the engines, and thereby their logistics support, LeMay reasoned:

> With those overheating engines, it began to seem that this high altitude stuff was strictly for the birds. The airplanes had been breaking down. There are something like 55,000 different parts in a B-29; and frequently it seemed that maybe 50,000 of them were all going wrong at once. I feel that the majority of our losses were due more to our own mechanical problems than they were to the Japanese defense system.
>
> Main thing to do, it seemed, was to get them down in altitude. Then we'd get a lot more hours' service out of each engine. And, since the bombing had been stinko most of the time, [we could] teach the crews to put patterns on the target. (2:343)

The gamble paid off almost immediately. The first pattern flown low was against a Burmese cement plant. The crews were able to increase their bombloads significantly as a result of requiring less fuel for climb-out. "When the smog cleared," LeMay recalled, "there was absolutely nothing left of that cement plant. Our people had done a perfect job."

LeMay added refinements to the low altitude incendiary tactic, such as removing bomb-bay fuel tanks and even all defensive armament, substituting night-time single ship and combat box patterns for large high altitude formation attacks, and intensified radar and precision bombing training. The results were described dramatically in the official history, *The Army Air Forces in World War II* (Vol V):

> The physical destruction and loss of life at Tokyo exceeded that at Rome (where 10 out of 14 wards of a much smaller city were consumed) or that of any of the great conflagrations of the western world-London, 1666 (436 acres, 13,200 buildings); Moscow, 1812 (38,000 buildings); Chicago, 1871 (2,124 acres, 17,450 buildings); San Francisco, 1906 (4 square miles, 21,188 buildings). Only Japan itself, with the earthquake and fire of 1923 at Tokyo and Yokohama,

had suffered so terrible a disaster. No other air attack of the war, either in Japan or Europe, was so destructive of life and property. (1:617)

The lower altitudes also allowed for larger bombloads which, in turn, caused another logistics problem. A shortage of fire bombs rapidly developed. Naturally, the pipeline to the Pacific, three months long, was filled with high-explosive bombs. (1:540; 541) It took several months for the supply to catch up with the change in tactics.

Roots of Current Doctrine

Many concepts formulated in the World War II Pacific theater influenced the way the Air Force operates today. Probably the most obvious is the centralized maintenance organization. General LeMay would further refine this concept after the War; in fact, it is still in use today in commands which find central control of resources effective. Also, the seed was planted for developing unified commands so that theater, rather than service, priorities would drive the operation of the support pipeline.

". . . logistical muscle and technique had to be developed before airpower could capitalize on its potential unique advantages of speed, range, and flexibility."

In the Pacific, as in other theaters, close examination reveals the extent to which logistical muscle and technique had to be developed before airpower could capitalize on its *potential* unique advantages of speed, range, and flexibility.

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DESIGN AND SUPPORT OF THE SUPERFORTRESS

"Few aircraft developed by the aviation industry and the AAF ever posed more problems than the B-29. Its size alone was a major consideration—in engineering, in production, and in testing. Time was another hurdle. It meant producing the biggest bomber in the least time with a minimum of second-guessing and redesign. . . .

"One of the most interesting aviation engineering feats of recent years is the story of the development of the power plants used on the B-29. Over 2,000 major and minor engineering changes have been made to date in getting this engine to a point of practical combat perfection.

"Because of its giant size, the air frame of the B-29 created thousands of other problems. Pressurization of the cabin was one of the biggest early headaches. Pressure cabins had been tried before with some success on other aircraft, but on a bomber the size of the B-29 the problem was tremendous. Today, in the giant bombers striking Japan, cabin pressure is efficiently maintained.

"With its 15,000 feet of electric wiring and electrically operated accessories, the B-29 is an electrical engineer's dream—and could have been a maintenance man's nightmare. It requires 129 electric motors, 26 motor-generators, and 7 generators to keep the B-29 flying, and each of these had to be designed for its specific job and built to stand up under varying conditions of climate and temperature with a minimum of care and replacement. There are some 55,000 numbered parts in every Superfortress. . . .

"As materiel and other problems were solved, production on the B-29 was stepped up. For security reasons, actual production figures cannot be given. However, it can be said that as 1944 drew to a close each plant producing Superfortresses, and there are a number of them, was completing on the average of more than one B-29 every 24 hours. As production increased, cost naturally decreased. The first B-29 cost $3,392,396.60. Those coming off the production lines today cost approximately $600,000. A total of 157,000 man-hours were required to produce the first B-29's to roll off the line; those produced today require only 57,000 man-hours. Despite the rush orders, the B-29 has been and is being brought up as an effective air weapon quickly and surely. The work today is just as intensive as it was and improvements are still being made. . . .

"A global Air Force must have adequate bases, a continual flow of parts and supplies, and a fool-proof system of rapid-fire maintenance. One example of how this was and is accomplished has to do with our installations on the island of Saipan. The operation was typical. On 30 June 1944, D-plus-5 day, the first Air Force Service Command units landed on Japanese-held Saipan to the accompaniment of hostile sniping, heavy artillery fire from near-by Tinian, and strafing attacks from enemy aircraft. For a time, the guns of those service units were the only antiaircraft defense on the field and their half-tracks had to maintain a constant patrol to prevent enemy infiltration. Thirty days later, Isley Field on Saipan was handling what was one of the greatest volumes of Army, Navy, and Marine air traffic in the entire Central Pacific Area.

"In order to support, supply, and maintain the Superfortresses in their raids on Japan, we organized new and streamlined maintenance service units. When AAF engineers had put the finishing touches on the airdromes on Saipan, these groups made their way ashore and began setting up their shops. In less than 3 weeks, their servicing facilities were in full operation providing aircraft with maintenance and repair.

"But even with such a streamlined organization, combat units sometimes get ahead of their service units. To forestall any such break-downs, we have organized aircraft repair ships—floating maintenance and repair shops manned by experienced airplane mechanics, propeller specialists, sheet metal workers, and other skilled craftsmen who can be moved to any spot where they are needed. Such a ship designed to service B-29's carries a stock of 137,000 spare parts for the Superfortresses and can do just about any repair job necessary to keep the big bombers flying against Japan.

"Strategically, except for the much greater distances involved, the B-29 is being employed against Japan in much the same way that our B-17's and B-24's are being used against Germany—to destroy the enemy's ability to fight by destroying his production of critical war equipment and his facilities for transporting this equipment."

***The War Reports of General H. H. Arnold* (1945).**

Civilian Career Management

LCCEP Rebaselining Position Structure

A major change is occurring in the Logistics Civilian Career Enhancement Program (LCCEP)! For several months, work groups from each major command have undertaken the task of establishing a new baseline of logistics positions for central career management. This initiative was in response to LCCEP Policy Council direction to grant the functional logistics communities within each MAJCOM the authority to determine which positions would be entered into LCCEP. This represents a significant shift in position management philosophy in relation to the emphasis previously placed on incorporating supervisory positions and establishing expected levels of participation for each grade.

On 19 August 1985, the LCCEP Executive Position Panel, chaired by Mr John Barton, Deputy Director of Materiel Management, Ogden Air Logistics Center (OO-ALC), and representatives of the Promotion Evaluation Pattern (PEP) Panel established the criteria to be used by the work groups during a Guidance Conference at the Office of Civilian Personnel Operations (OCPO), now the Air Force Civilian Personnel Management Center (AFCPMC). The goal of rebaselining was to establish a stable group of centrally managed positions to serve as the framework for the development of top-quality professional logisticians to meet the needs of the Air Force today and tomorrow. Concurrent with identification of positions to be managed centrally,

TO 8 ▶

General Kenney on Far East Supply Concepts

When we went into the Philippines it was at a time when Europe seemed to be needing more shipping than it had ever needed before, and that minor war over there was surely absorbing a lot of everything. So they cut down the number of boats that we had, and we were really in tough straits. When we first went into New Guinea we had this bright idea that you couldn't do anything unless you had a 120-day stockage of everything. We cut that down to 90, with some misgiving on the part of MacArthur's supply crowd, and then I cut it to 60, and even to 30, and even the Air Force began to howl about 30 until they saw that Air Transport could pick up the slack.

When we started into the Philippines the shortage of shipping was so acute that we landed on the island of Leyte with five days' stockage, and we never got more than five-day stockage, and we didn't want more than that because by this time we had air supply. We were flying gasoline, we were flying bombs, we were flying food, we were flying stuff for the infantry as well as ourselves. We were really doing a job with air transport. Where in the original part of the game we had to build warehouses and set up a depot and build terrific warehouses to stock stuff in, and the stuff would get spoiled in that bad weather and everything, now we didn't have any stockage in there at all to amount to anything. These depots were largely depots repairing wrecks, and if we needed a spare part we would fly the thing in. We would fly engines in. We were overhauling engines in Australia, and as the thing got off the test stand it went right into an airplane, and inside of five or six hours they were putting it in a bomber up in New Guinea.

Suppose, on the other hand, you do it the old fashioned way. You take the silly engine off here and disassemble half of it and wrap it up in little packages, and they get lost when they open the crate. Everything is supposed to be proof against this damp tropical weather and proof against the salt spray that they get, because they always put our stuff on the decks.

These big heavy crates are made so you can drop them from the crane to the bottom of the hold, in case they did put them in the hold, and not break anything, and everything is filled up full of cosmoline, and then they load these boats until they have enough for a convoy. A month goes by. This thing has gotten all rusted, and the pistons won't move, and the crankshaft had red spots on it, and when you do get the cosmoline off of it you haven't an engine until two months have gone by.

There was no doubt, as soon as we started in doing this stuff, that that was the way to run a fast-moving war, especially when you were on a shoestring, and we finally found out that the way to run a war was on a shoestring anyhow, that that was modern war, faster, and the whole Pacific campaign that MacArthur had would still be going on trying to get out of Port Moresby if it hadn't been for the transport.

General George C. Kenney
Speech for Air Force Association, 1952.

the Panels tasked the work groups to correct the classification and skill coding anomalies in similar positions at different locations that have impeded PEP development in the past. Major command nomination packages were to be submitted by a target date of January 1986.

Pending review by the Position and PEP Panels, the new baseline could be in place as early as April 1986. Copies of the new baseline will then be distributed to all CPOs for their information and to assist LCCEP registrants in career planning.

For the aspiring Cadre member or program registrant, the rebaselining process will undoubtedly alter the structure of the 2,056 LCCEP positions in the program as of 1 January 1986. Some positions will be removed as a result of MAJCOM prerogative, but many others will be added. While it is still too early to accurately forecast the outcome of rebaselining in terms of numbers of positions actually added or deleted, all concerned should review their career goals in the months ahead for opportunities available through the new baseline.

Positions have always been central to the success of the LCCEP. AFCPMC envisions rebaselining will serve to expand both competition for, and the availability of common positions across, functional and command lines. The added stability afforded through MAJCOM position nominations will allow logisticians to target clearly their career paths within LCCEP as never before. Also, rebaselining will provide a positive direction for the LCCEP and will result in constructive development for logisticians throughout the Air Force.

(Source: Clayton F. Brumit, AFCPMC/DPCCLO)

Military Career Management

Assignments

The Aircraft/Munitions Maintenance Officer Assignments Section of Palace Log recently forwarded an assignments newsletter to all commanders/supervisors of maintenance officers. In the letter, they outlined some "Rules of Engagement" used when working assignments. The basic philosophy applies to all logistics officer specialties.

RULES OF ENGAGEMENT

We know some of you consider us (AFMPC) an adversary, but it does not have to be that way. Let us lay out the ground rules so everyone will know how we do business.

a. Unless in a "must move" status (DEROS, end of controlled tour, graduation from school, etc.), we do not plan to move an officer at any specific time. Overseas requirements drive the system. One-fourth of the AFSC 40XX positions are overseas, with four percent of the total in short-tour areas. (All logistics specialties bear this characteristic; i.e., about 25 percent of all assignments are overseas - Ed.) Each move is driven by the need to fill a valid Air Force requirement. We cite three years as a potential movement point because DOD rules designate three years as the minimum time-on-station for CONUS-to-CONUS PCS without waiver. The average time between arrival on station and receiving orders for AFSC 40XX officers is approximately 27 months. (Same average for all logistics specialties - Ed.) This time period is partially driven by overall AFSC 40XX manning. Currently, there are almost 300 vacancies worldwide. (630 for all of logistics - Ed.) The only way to effectively manage those gaps is to pass them around to each organization. We move officers overseas based on their volunteer statements or vulnerability for overseas, and move officers in CONUS based on their time-on-station. In both cases, *qualification* for the proposed job is the primary driver. That is why we sometimes move an officer with 18-24 months on station.

b. Before finalizing any assignment, we will call or write you. Here is where the misunderstanding sometimes begins. Listen carefully to what the assignments officer says when he/she calls. If you are a volunteer, for example, for an overseas assignment, the information given you will indicate you are now the most eligible, qualified volunteer, and MPC is beginning to process the assignment for which you have asked. If you have not been a volunteer, or had not expected to move, the thrust will most likely be centered around your vulnerability for a specific position, or maybe a group of positions. In either event, this call is your opportunity for input. If you believe this assignment does not fit you, tell the caller why and your input will be made a part of the assignment decision.

c. We will also call your current MAJCOM/agency, perhaps before calling you. We want to give them a "heads-up that we are interested in moving you" and determine if they have a plan for you they have not shared with us up to this point.

d. The next step involves the gaining MAJCOM/agency. They want to know about the new officer they are receiving. The primary purpose of this contact, unless the position to be filled is a selectively manned position, is to make sure we have "hit the target" with the type officer required for the position.

e. After all these inputs, we will make the assignment decision. If it is to be completed as planned, we will make one final contact with the losing and gaining MAJCOMs/agencies before we load the assignment in the Personnel Data System. After we make the computer input, your commander/supervisor will call you in approximately ten days with official assignment notification.

The system sounds rather laborious, but it is based on the premise assignments should not come as a surprise to any of the parties. We work the system hard, and although everyone may not be entirely satisfied with their final assignment, they have all had an opportunity to make an input and their recommendations have been considered. The hardest thing to accept when you are on the receiving end is the fact that Air Force requirements sometimes do not coincide with individual and MAJCOM desires.

Career plans need to be built around career development. Individuals should determine what *type* of job and *level* of assignment suits them personally. They should talk with their commanders about their aspirations. Then they should clearly describe these plans/desires on an Air Force Form 90. All AF Forms 90 are retained in the Assignments Section at AFMPC, and they allow assignment personnel to try to match requirements with desires. Conscientious completion of an up-to-date Form 90 still remains the best starting point for an assignment that coincides with individual career goals.

(Source: Lt Col E.C. Humphreys, III, HQ AFMPC/DPMRSL (Palace Log), AV 487-4553)

66XX/661X0 Career Field Review Group Meeting

In December 1985, the Directorate of Logistics Plans and Programs, HQ USAF, met with Logistics Plans functional managers (for the first time) to review the 66XX/661X0 career field, establish the career field's direction, and determine if new or revised goals are warranted. The meeting was called in response to the career field's large growth in the last several years and its perceived division into specialty areas. The Air Staff Logistics Plans community perceives that the career fields need to be refined—or redefined—to remove extraneous workloads thrust upon logistics planners over the years. This redefinition would be intended to permit log planners to "do what they do best": planning, programming, integrating, cross-functional innovating, and objective cross-checking.

The group first reviewed principal regulations dealing with logistics plans and delineated proposed changes which clarify career field responsibilities. Second, it began reviewing and evaluating all 66XX/661X0 authorizations with two questions in mind:

(1) Does the position really require a "66"?

(2) Could an AFSC other than "66" do the job equally as well or better?

The current review and evaluation are meant to be an exercise in which *functional managers* conduct *in-house* reviews and evaluate their respective 66XX/661X0 positions in terms of the above questions. Ultimately, recommendations will be coordinated or negotiated through other logistics, manpower, and personnel policymakers.

(Source: Major Dave Fortna, AF/LEXX, AV 227-8648)

The Logistic Warrior

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In the highly significant historical work, *Supplying War,* Martin Van Creveld chronicled the logistical dimensions of key military campaigns from the seventeenth century to the Allied invasion of occupied Europe. Rooting his conclusions in rigorous research and keen analysis, he suggested logistics is nine-tenths the business of war.[1]

General Sir Archibald Wavell expressed the same view in reflecting on his World War II experiences:

> The more I see of war, the more I realize how it all depends on administration and transportation. . . . It takes little skill or imagination to see where you would like your army to be and when; it takes much knowledge and hard work to know where you can place your forces and whether you can maintain them there. A real knowledge of supply and movement factors must be the basis of every leader's plan; only then can he know how and when to take risks, and battles are won only by taking risks.[2]

Both Van Creveld the historian and Wavell the combat leader confirm the massive role of logistics in military operations. This places a heavy burden on Air Force logisticians to be much more than the supply specialists, maintenance teachers, and transportation experts for which our education and training prepare us. It enjoins us to think, not only as logisticians, but as strategists and tacticians. In short, we must be *complete warriors* with the minds of commanders as well as logisticians.

"Only the warrior can understand war."

In this spirit, I offer three historically validated observations about the character of combat: First, war is a dangerous and uncertain activity that will tax a person's mind, body, and spirit to the limits. In war, Murphy's Law is the rule rather than the exception. Second, war is more art than science. It is an activity dominated by improvisation and ingenuity. It is essentially a human activity—a contest between thinking, emotional beings. It is not a battle of machines. Third, only the warrior can understand war, and the warrior is our best hope for improving both our deterrent and war-fighting capability. Each of these points deserves some elaboration.

The Stress of War

When Clausewitz talks about war, he uses the term *friction* to describe its essential characteristics. These characteristics include the paralyzing, visceral impact of danger in war; the extraordinary exertion combat imposes; the irreducible distortions and uncertainties inherent in the diverse information on which action in war must be based; and the inevitable obstacles to action that arise from the play of chance and the enemy's unpredictability.[3]

War is dangerous. People are killed. They are stressed. They are often deprived of the essential necessities of life. War produces a punishing and unforgiving environment. From 1939 to 1945, 60% of the Bomber Command aircrews were killed. German losses were even more catastrophic; more than 90% of their fighter pilots failed to survive the war.[4]

"The Israelis attributed 30% of their casualties to battle stress."

Death, however, is not the only phenomenon of combat. During the 1973 war, the Israelis attributed 30% of their casualties to *battle stress.* Moreover, they found reservists and support personnel the most prone to stress. I would argue these support troops were not as mentally well prepared for battle as their active combat counterparts. Further, it is likely their situation parallels our own. Air Force logisticians have had the luxury of operating from the relative security of base sanctuaries and have rarely had to experience battle directly. Therefore, some of us may lack the war-fighting *will,* if not the skill.

Clausewitz wrote of exertion and how trying to do even the simplest thing in war is difficult:

> Action in war is like movement in a resistant element. Just as the simplest and most natural of movements, walking, cannot easily be performed in water, so in war, it is difficult for normal efforts to achieve moderate results.[5]

This exertion is due in large part to uncertainty—the failure of events to follow plans. We often call this "Murphy's Law"; Clausewitz called it the "fog" of war.

Even in science, certainty has become suspect. As Jacob Bronowski noted:

> One aim of the physical sciences has been to give an exact picture of the material world. One achievement of physics in the twentieth century has been to prove that that aim is unattainable. . . . *There is no absolute knowledge.* And those who claim it . . . open the door to tragedy. All information is imperfect. We have to treat it with humility. That is the human condition.[6]

This view of uncertainty is being reconfirmed in our own studies with the Rand Corporation concerning demand rates for aircraft components. We are discovering the "variance to mean ratios" for demand give us little confidence in being able to predict combat needs in the aggregate or at specific operating locations.[7] This reality suggests we need to restructure our distribution systems to mitigate the effects of uncertainty.

Not only does one have to contend with the inherent uncertainty of material phenomenon, but the *human* (psychological) element makes the fog of war even more "dense." As one astute observer noted in World War I, about 90% of all reports to higher headquarters were false or exaggerated. Everyone was subjected to tremendous nervous

strain, imaginations ran wild, and danger threatened at every turn. Couple this uncertainty and unpredictability of friendly forces with the ingenuity of a determined enemy, and you can begin to appreciate the complexities and nuances of warfare.

"Surely the Soviets intend to compound the fog and friction of war."

Surely the Soviets intend to compound the fog and friction of war. Soviet doctrine calls for the skillful exploitation of initiative, surprise, and shock to paralyze an enemy's will and destroy his morale. An important element of this doctrine is a concept called *Maskirovka,* or deception. When General Nikolay Ogarkov was promoted to General of the Army, his main assignment was the reactivation of the chief directorate of strategic deception.

These facts suggest another conclusion about armed conflict: War is essentially a human activity dominated by a contest of human wills and intellects. In other words, war is more *art* than *science*.

The Art of War

Clausewitz disagreed with his contemporaries like Henri Jomini, as he also would with our own Air Force technocrats. He found:

> *They* aim at fixed values, but in war, everything is uncertain. . . . *They* direct the inquiry exclusively towards physical quantities, whereas all military action is intertwined with psychological forces and effects.[8]

Although we logisticians complain we are often ignored and, worse, discounted by the operators, our influence has been greater than we might otherwise think. As Colonel Barry Watts documented in his book, *Foundations of U.S. Air Doctrine,* our approach to aerial warfare from the start has had a very mechanistic, materiel bias.[9] The Air Corps Tactical School of the 1930s formulated the following thesis:

> The most efficient way to defeat an enemy is to destroy, by means of bombardment from the air, his warmaking capacity. The means to this end is to identify by *scientific analysis* those particular elements of his war potential the elimination of which will cripple either his war machine or his will to continue the conflict.[10]

This doctrine eventually evolved into a target system composed of four basic groupings: electric power generating plants and switching stations; transportation (marshaling yards, bridges, and locks); petroleum plants; and aircraft plants (assembly, aluminum, and magnesium plants). To this day, this mechanistic "engineering" approach persists, suggesting somehow that war can be reduced to some finite target sets.[11]

This approach also presumes *attrition* warfare is the most likely, if not the most desirable, method for war fighting. Attrition warfare presumes superiority in materiel with the most important decisions being primarily logistical. But against the Soviet system—the best integrated military-industrial complex—we would be wise to learn to think *better,* not *bigger*.

Of course, an unwarranted faith in technology is not the answer either. As defense critic Jeffrey Record writes: "Technology was *indecisive* in Korea, *irrelevant* in Vietnam, and *unreliable* in Iran." Record goes on to assert that our military training and education disregard the fact that war is, first and foremost, a human encounter determined less by the management of quantifiable ingredients than by the intangibles of leadership. He views the U.S. Military as a vast bureaucracy with corresponding values of career advancement, an orderly flow of people and paper, and self-protectionism. In short, he considers the distinguishing characteristic of the American officer is a singular *lack of interest in the art of war*.

The Logistic Warrior

This view is distressing because *only* warriors can truly understand war. And, because logisticians are vital to battlefield success, they too must become warriors through study, practice, and reflection on the teachings of military history.

Edward Luttwak, in *The Pentagon and the Art of War,* expands on Record's accusation that the officer corps has lost its effectiveness. He does not place the blame so much on the individual officer, but rather on the organizational *structure* that prevents the officer from planning and fighting effectively. Luttwak contends that officers are functionally organized and compartmentalized so responsibilities must be shared between competing agencies. This diffusion of authority and responsibility, although acceptable in peacetime, becomes *debilitating* in war.[12] In essence, Luttwak, Record, and many others accuse the military of being indistinguishable from our civilian counterparts in the way we think and act—we allow peacetime methods to obstruct our wartime preparedness.

"We allow peacetime methods to obstruct our wartime preparedness."

The point is further supported by Franklin Spinney's view of the world of weapons acquisition. Spinney believes complex weapon systems exhibit low combat readiness because of reliability and maintainability deficiencies. Further, increased complexity increases combat vulnerability due to dependence on a large support structure. This support structure in turn undermines the efficiency of plans and degrades war-fighting skills by reason of inadequate or unrealistic training. Moreover, Spinney emphasizes, complexity increases susceptibility to the frictions of war and slows modernization by lengthening development and procurement lead times. Finally, increased complexity, due to increasing costs, reduces our overall force structure and stockpile of supplies. All this adds up to diminished combat capability.

Put another way, one Israeli General observed that "U.S. weapons are designed *by* engineers *for* engineers whereas Soviet weapons are designed for the combat soldier." Clearly, as distant as the laboratory may seem from the battlefield, our system acquisition community must develop a deeper feeling for the tasks of the warrior.

This is no less important for operational command logisticians who convert weapon systems into dynamic tools of war. Throughout our structure, valid military *methods* must be clearly understood and take precedence over the "business management" ethic. During Operation Overlord, Army logisticians overplanned the Normandy invasion and tried to adhere to a rigid order of priorities in unloading supplies onto the French beaches. In effect, they stifled the flow of supplies

by stopping, rather than allowing, the unloading of lower priority cargoes when they were out of position in the queue. In a nutshell, these logisticians neglected to account for the friction of war. And in their attempt to be more efficient, their inflexibility led to even greater inefficiency. The resulting interruption in supply reverberated from one end of the pipeline in France all the way back to England and beyond.[13]

Admiral Henry Eccles made similar observations with regard to command and control of distribution in the Pacific Theater. He noted that, in peacetime, movements were of less volume and more predictable than they were in combat and could operate effectively with a high degree of centralization. However, in wartime—with greater volume, greater urgency, and less predictability—the centralized system could not handle the necessary work load.

"How do officers prepare themselves for war?"

Repeatedly, history tells us war is not like peace. We logisticians must debunk the myth that the Air Force will operate in wartime like it does in peace. We must understand the differences and develop logistical concepts and systems capable of withstanding the rigors of a *real* test. *So, the question remains: How do officers prepare themselves for war?*

Luttwak tells us the military structure is so seriously flawed that we are incapable of changing the system from within. He asserts a refocusing can only be accomplished from outside the Department of Defense. He may be right, but we must act as if he is *dead wrong*. We must change the focus of our education and training institutions, and we must change ourselves. We should place military history and doctrine into our curricula at both professional and technical schools. And changing our curricula is not enough—we must also change our individual mind sets. We logisticians must think and act like warriors.

This task is an individual responsibility. I would even go so far as to declare it a *moral* responsibility since our profession carries such a high price for failure. I enjoin all Air Force logisticians to make a personal commitment toward a professional reading program. Read regularly and routinely about war. Read with a purpose to learn all you can about being a military leader and logistician.

* * *

A statue at the Air Force Academy reads, "Man's flight through life is sustained by the power of his knowledge." Knowledge about war can come only by studying and reading about war and warriors. The responsibility is an individual one. History confirms that wars cannot be won, nor peace sustained, without a strong logistical base, either supplied in great mass or wisely metered out for maximum effect. We can no longer count on mass, so our judgement must be keen and our wisdom practical. We must think in the medium in which we would be ultimately tested—as logistic warriors in combat.

Notes

[1] Van Creveld, Martin. *Suppling War*, Cambridge University Press, 1977, p. 231.
[2] Wavell, A.C.P. *Speaking Generally*, 1946, pp. 78-79.
[3] Paret, Peter, and Michael Howard. *On War*, Princeton University Press, 1976, pp. 119-121.
[4] Murray, Dr. Williamson. *Strategy for Defeat: The Luftwaffe, 1933-1945*, Air University Press, 1983, p. 303.
[5] Howard, Michael. *Clausewitz*, Oxford University Press, 1983, p. 26.
[6] Bronowski, Jacob. *Ascent of Man*, Boston: Little, Brown and Co, 1973, p. 352.
[7] Blazer, Lt Col Douglas J. "Variability of Demand: Why the Part is Never on the Shelf," *Air Force Journal of Logistics* (Spring 85), p. 11.
[8] Paret and Howard, p. 136.
[9] Watts, Barry D. *Foundations of U.S. Air Doctrine*, Air University Press, 1984, p. 22.
[10] Ibid., p. 18.
[11] Ibid., p. 19.
[12] Luttwak, Edward N. *The Pentagon and the Art of War*, S&S Publishing, 1985.
[13] Van Creveld, p. 210.

The Legacy of Warriors

Excerpt from address by General Donn A. Starry, Ret., marking the rededication of the 11th Armored Cavalry Regiment monument at Fort Knox on 11 May. Starry commanded the regiment in Vietnam.

Now, I know war is out of fashion.

I also know that war can be frightening, exciting, even dull.

But, I know, too, that after time has passed, it becomes evident that war's message was perhaps more divine than profane.

That's why we need occasions like this one—to gather round once more to reflect on the example that the lives, the service, the sacrifice, of these men and their families represent to us, the living.

We need occasions like this to remind us that our relatively comfortable routine is really just a little piece of calm in an otherwise tempestuous world, so that, being reminded, we may be better prepared for danger when danger finds us, for find us it will.

We need occasions like this in times of individualist negation, of cynicism, of seeking after personal well-being at the expense of all else, of denying that anything is worthy of reverence; we need them to remind us of all things the buffoons would have us forget.

For the ultimate challenge of war's danger teaches us to believe things our doubting minds are soon to prove for themselves: out of heroism grows faith in the undying worth of heroism.

I do not profess to know any ultimate truths.

Nor do I pretend to know the meaning of the universe.

But in the midst of doubt about values; in the collapse of beliefs and creeds, in the denial of the virtues of duty to God, fellowman, country, there is one thing I do know beyond all doubt.

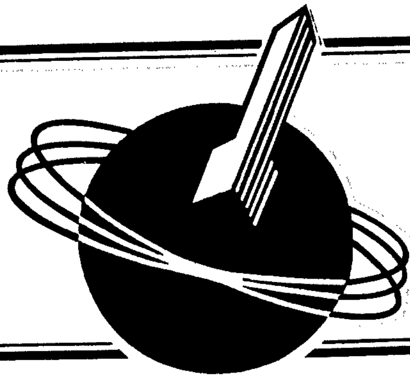
And that is: That faith is a true faith that brings soldiers to risk and sacrifice their lives in acknowledged duty, in a cause they may imperfectly understand, in a battle whose plan of campaign may be to them obscure.

Having tasted of battle, the warrior knows the cynic force with which reason assaults the human mind in time of stress. The warrior knows well the vicissitudes of humor, terror, victory and death in war.

But in a larger sense the warrior knows the joy of life is in the living of it; that, as one of them said—to those who fight for it, life has a meaning the protected can never know; that the ultimate worth of war's challenge is that it forces men to bring their full power to bear, stretched as far as their capacity will allow, in order to solve life's most difficult problem—fear.

Above all, these warriors speak to us with but a single voice—one which rises over the dissonant sounds—one which reassures us that man has in him that unspeakable something that makes him capable of a miracle; able to lift himself above the commonplace by the might of his own will; able to face annihilation based on faith in his God, faith in himself—in his warrior's soul—and faith in the men who are his comrades in arms.

That is the legacy left us by these warriors; it is a large legacy; it is perhaps larger than we deserve.



Space—The Logistics Challenge

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Buck Rogers captured the imagination of Americans in 1929 with his adventures and dreams of space travel, rocket belts, and space stations. Buck was the first astronaut, doing everything from exploring the galaxies to repairing his space ship. This also made him the first space logistician. The writers who penned the Buck Rogers series had tremendous foresight and imagination. If they could have been around 50 years later, they would have witnessed the amazing reality of space—not just a fantasy.

The race for space began when the Soviets launched their first Sputnik satellite in October 1957. The United States countered with its Explorer I satellite four months later and, since then, has put men in earth orbits, landed men on the moon, walked in space, and built a shuttle to pluck satellites from low earth orbit and repair them in space.

Although achievement of these technological goals is spectacular, the cost is enormous.[1] The shuttle took approximately $14 billion (in 1985 dollars) to develop and costs from $42 million to $150 million per flight, depending on the accounting method used.[2] The shuttle has provided a tremendous technological shot in the arm and is an extremely versatile vehicle. But its cost is an order of magnitude over original projections.[3] We must anticipate the future better and generate more cost-effective ways to provide required operational capabilities to maintain our technological leadership in space.

Space operations are customarily viewed in terms of four interrelated segments. The *launch* segment inserts spacecraft into orbit or elsewhere in the space medium; the *space* segment includes on-orbit operations and servicing; the *control* segment monitors spacecraft health and directs operations; and the *user* segment operationally interacts with the space segment to give utility to operations. This article addresses logistical challenges of the *space* segment, many of which naturally involve and impact other segments.

Major Requisites for Success in Space

Maintaining our present edge in the space segment requires the development of four new capabilities. Each is of paramount importance to our advancement in space and is at some stage of definition in the National Aeronautics and Space Administration (NASA) or Department of Defense (DOD).

Space Station. In January 1984, President Reagan directed NASA to develop a permanently manned space station within a decade. Its mission is to provide a space laboratory for conducting scientific and technological experiments. The space station will also act as a permanent observatory, a communications and data processing node, and a transportation node for satellites between orbits. Use of the space station in the 1990s and beyond is virtually limitless, with most intriguing logistics possibilities—a space repair depot, a satellite servicing center, and a launching pad for spacecraft into high earth orbit.

Heavy Lift Booster. While the shuttle provides many on-orbit capabilities, the launch capacity of the shuttle is confined to 47,000 pounds. Further, the turnaround of each shuttle is expensive and time-consuming. A high payload/low-cost expendable booster will be needed in the next ten years to place numerous satellites in orbit (including high earth orbit) simultaneously and also provide large resupply payloads for the space station.

Orbital Maneuvering Vehicle (OMV)/Orbital Transfer Vehicle (OTV). Vehicles to shuttle back and forth between the space station and retrieve satellites in high earth orbits are critical to cost-effective space use, although we probably will not see these spacecraft in the 1990s. Our in-space transit system, whether manned or robotic, must have the capability to capture satellites and return them to the space station for repair and servicing or for staging and return to earth. A potential second generation OMV could include the robotic servicing of satellites in their orbit.

National Aerospace Plane (NASP). Called by several other names, the concept of a horizontal "take off to space/land like an airplane" vehicle remains the same. The NASP will provide the US with immediate access to space. It will also provide low-cost access to orbit and the ability to reach mission critical space assets quickly for rescue missions. The national security and space access implications of the NASP are very significant; therefore, we must continue its development.

Logistics Challenges

But, if the operational costs of these assets are to be acceptable, effective logistics concepts must be finalized and incorporated before system design proceeds much further. Logistical challenges face us in at least five areas:

- Providing for on-orbit servicing and assembly.
- Developing design standards.
- Making repair versus "throwaway" decisions.
- Designing to life cycle cost targets.
- Applying integrated logistics support techniques.

On-Orbit Servicing and Assembly

The term on-orbit logistics (OOL) encompasses the repair, servicing, and assembly of crafts in space.

Repair and Servicing. As a frame of reference, consider what happens today to a satellite that fails in orbit. In most cases we are limited to abandoning and replacing the lost vehicle. This is costly, especially if the satellite fails prematurely, fails to reach the proper orbit, or does not initially "turn on." Although we use the shuttle to launch satellites, it has not been a dependable launching pad for satellites to *high earth* orbit. It has, however, been used effectively to retrieve and repair spacecraft.[4] The retrieval capabilities of the shuttle were initially demonstrated on the

"We are now able to add the words recoverable, repairable, and serviceable to our space logistics lexicon."

Westar and Palapa satellites in early 1984. The 1984 retrieval and on-orbit repairs of the Solar Max Mission and Leasat satellites were the first significant US logistics maintenance actions in space. The return to service of the Solar Max and Leasat satellites saved us almost $300 million. We are now able to add the words *recoverable, repairable,* and *serviceable* to our space logistics lexicon. These are the events upon which we logisticians must build.

Some of the logistics events already demonstrated on orbit include transferring hydrazine fuel, capturing spinning satellites, erecting structures, and effecting various repairs. Many more such actions are planned. As technology and procedures are demonstrated in space, we can expect to eventually service satellites just as we do aircraft. Each will be scheduled for maintenance at specific intervals, whether on orbit or at space station repair facilities. Orbital replaceable units (ORUs) can be developed similar to the way we use line replaceable units (LRUs) on aircraft. We can also use these service intervals for replacing/repairing instruments on board, incorporating equipment upgrades and modifications, or adding additional capabilities.

Assembly. As the national space infrastructure grows, manned space activities will also expand. On-orbit assembly and construction of large space structures should begin in the 1990s, starting with the space station. The crew of NASA Shuttle Mission 61B recently demonstrated techniques for construction and assembly in space. The astronauts spent 12 hours in space building and tearing down a 45-foot truss tower and assembling and dismantling a large pyramid structure.[5]

Standards for Components and Interfaces

Currently, when the DOD, industry, or NASA launches a satellite, the specifications used to build that satellite are all different. No standards exist for interchanging modules, replenishing fluids, and the like. We must correct this in the near future. Mechanical interfaces, connectors, and modularity are all areas where design features, considerations, and guidelines must be worked. DOD, NASA, industry, and our allies must cooperate to establish these standards.

On-Orbit Logistics. The Space Division of Air Force Systems Command (AFSC) took the first major step in on-orbit logistics by selecting contractors to complete a major Space Assembly, Maintenance and Servicing Study (SAMSS).[6] The consolidated requirements will include identifying areas where on-orbit maintenance and servicing will enhance the system while lowering overall life cycle costs; exploring commonality opportunities among space systems; and consolidating requirements to identify common system performance and SAMS requirements such as size, orbit, attitude maneuvering, power, communication, consumable fluids, thermal control, optics, antennas, and structures. The study will also investigate space hardware/tools and their impact on design and will develop a SAMS mission model. While there have been other studies, the SAMSS will hopefully provide the vehicle for interagency cooperation. This is especially true in the standardization area, since the design detail of the SAMSS will be used in the parallel Spacecraft Standardization Study (SSS). The SSS will develop strawman standards for review at a government and industry open forum in 1987. In the author's opinion, OOL of our future on-orbit systems will be no better than it is today without such a set of standards.

Incentives. We must, however, provide *incentives* for standardization. Companies are not particularly interested in taking the lead because they build spacecraft for profit. The company that builds a satellite owns all the data, and only that company will be able to supply parts and modules for the satellite. This leads to sole source contracting, our most expensive way of doing business. If we standardize, DOD/NASA would be able to compete for the form, fit, function (F^3) design of parts, thus lowering cost considerably. System program offices must be directed to take the risk of incorporating standardization requirements in their contracts in order to improve long-term returns on investment.

Repairable Versus Expendable Spacecraft

The question today is not "whether," but "how, when, and by whom" our space assets will be logistically supported. This should be determined during satellite design, during which many alternatives are considered and tradeoffs evaluated. Considerations should include the option of revisiting satellites in orbit. Some features might include provisions to allow for safe approach, grappling and holding the satellite, fluid and electrical interfaces, and built-in test. When considering whether to include these features into the design of a new system, costs (in both dollars and weight), paybacks, and tradeoffs must be examined.

Figure 1 depicts OOL considerations for our next generation of spacecraft. We now have the capability to use complex

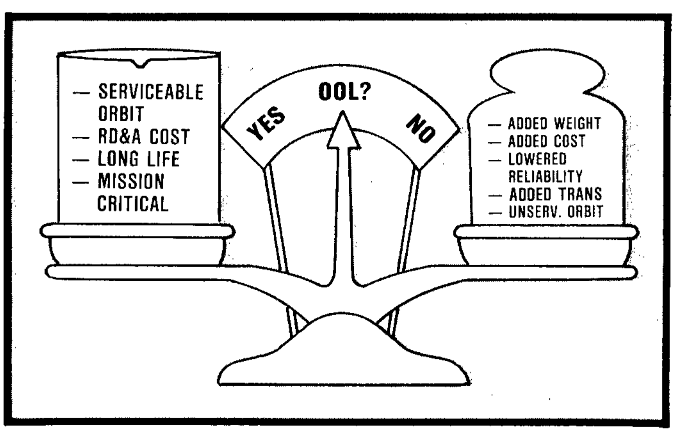


Figure 1: On-Orbit Logistics Considerations.

modeling techniques to help make the tradeoffs. Such a "Design for Logistics" analysis would also include the added cost for transportation to revisit satellites. Keep in mind the repair activities on Leasat and Solar Max saved almost $300 million—enough to pay for two shuttle missions.

Design to Life Cycle Cost

We must do in space what earthbound logisticians have been demanding for years—design to life cycle cost (LCC). Traditionally, logistics considerations have *followed* operational requirements. The Air Force has demanded the fastest, most maneuverable fighter aircraft and the biggest payload cargo aircraft. But this "biggest, best, fastest" syndrome often left out the up-front logistics provisions for properly supporting these aircraft during their operational years (fortunately, the trend appears to be reversing in the aircraft arena). To avoid this logistics pitfall in the space medium, we must evoke integrated logistics support principles now if we are to support our space program beyond the year 2000.

The cost curve in Figure 2 roughly reflects how we design a satellite today—built to last with emphasis on redundancy and high reliability. The longer a unit is intended to last, the more

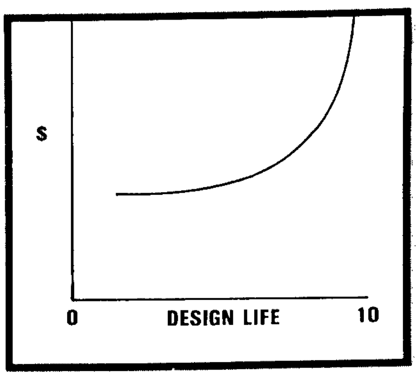


Figure 2: Reliability Cost as a Function of Design Life.

its initial cost. This is standard procedure for high earth orbit satellites today. The equation for maximum life at lowest cost is "availability equals reliability." The mean mission duration (availability) of the satellite is targeted to the design life. We build satellites with phenomenal reliability and redundancy hoping that the satellite will continue to operate until the consumables (fuel and batteries) run out. But if we were to insert OOL considerations into this equation, the mean mission duration would become *greater* than the design life.

To depict this, Figure 3 shows two curves. One curve shows the cost of putting up a new satellite every four years, reflecting primarily research, development, and acquisition (RD&A) costs plus transportation to orbit. The other curve reflects the life cycle cost of this concept if we were to build OOL into the satellite and then visit it every three years for servicing. This curve depicts variable operations and maintenance (O&M) and transportation costs, plus initial RD&A fixed costs. The portion of this equation for transportation has been predicted to be from 20% to 40% of the total cost to put a new satellite in orbit. If we use 30% for transportation and assume a 10% factor for modular exchange, repair, and servicing, OOL would save a considerable amount over the projected life of the satellite.

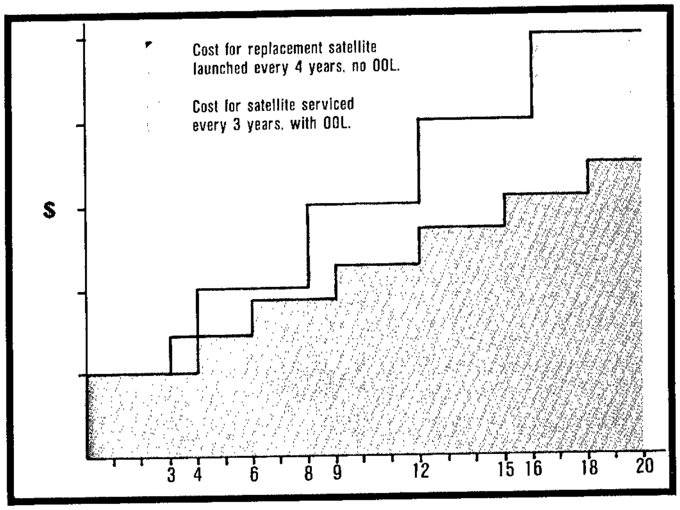
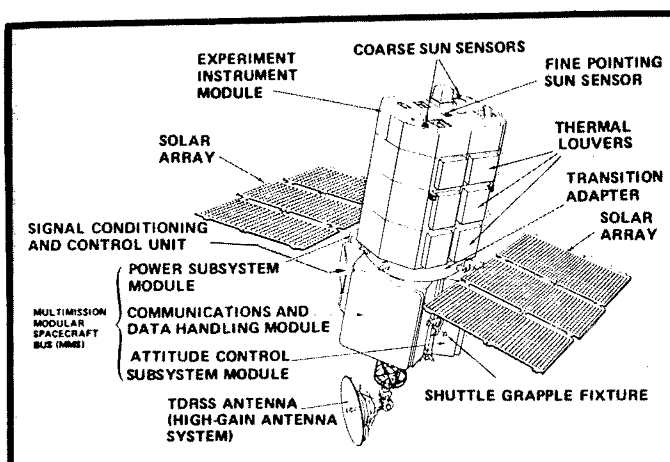


Figure 3: Relative Costs of Design Approaches.

Obviously, the more frequent a satellite is visited for repair/service, the greater will be the O&M cost. By designing to the lowest *total* cost, the optimum mix of reliability and maintainability can be incorporated into the design. The resulting LCC figures can be compared to a "design for reliability only" approach to determine the best acquisition strategy.

One factor which favors incorporating OOL into a satellite is that, if it fails prematurely, the ability to return it to service is incorporated. For example, a $100 million satellite built to last 10 years costs an average of $10 million a year *if it lasts* its full design life. If it fails prematurely, the yearly cost of the satellite increases accordingly. If the same $100 million satellite fails before its tenth year but has OOL incorporated, the satellite can still be returned to service to complete its full service life. The only added cost would be to revisit the satellite.



The Solar Maximum Mission (SMM) satellite was the first spacecraft to be repaired and returned to orbit.

The first test of this "designed for OOL" philosophy is expected in late 1986. NASA plans to launch the *space telescope*, the first system designed for limited servicing and repair. The decision to incorporate maintainability features was based on the telescope replacement cost ($400-$600 million) and its accessibility. As currently planned, the shuttle will rendezvous with the space telescope to replace its batteries and scientific instruments every three years and its solar arrays every four to five years.

Our challenge today as logisticians is to use advancing technology to the benefit of our nation. We know the capabilities are available, and we know the logistics technologies to support these capabilities are increasing. The principles of integrated logistics support (ILS) management are as important in planning for space as they are for ground systems—perhaps more so. Incorporating ILS elements such as equipment, transportation, technical data, supply support, and training into space systems is a challenge we face and must deal with today.

This means we must consider the logistics support elements *up front*—during design, not after. Engineers can then *plan* for satellite repair and servicing. An analogy can be drawn to baking a cake; all the ingredients must be included in the mixing bowl because, when the baking pan hits the oven, it is too late to change the outcome. This preliminary work is the most important action we can do now for the space systems of the 1990s and beyond.

If we fail to do our logistics homework now, the long term impact on national security could be severe. Consider the President's Strategic Defense Initiative (SDI). The SDI research program will provide to a future president and congress the technical knowledge required to decide whether to develop and deploy advanced defensive systems.[7] If deployed, the system could include directed energy weapons; kinetic energy weapons; command, control and communication satellites; and surveillance, acquisition, tracking, and kill assessment satellites.

These technologies are expensive and, while the final number of assets needed for an operational SDI system remains speculative, we know it will be formidable. At the same time, we also know it must be *affordable*. Even if technologically feasible, our leadership could hardly consider development of an *unaffordable* system. Therefore, trying to accomplish SDI without considering the economic benefits of OOL would be foolish. It is no wonder that many SDI Phase I architecture proposals submitted by contractors have included some degree of space-based maintenance considerations.

Conclusion

We must explore the space arena with the ultimate objective of accomplishing operational requirements with the most cost-effective systems possible. This translates to maximum *availability* at the lowest *life cycle* cost. Five thrusts are, I believe, crucial to achieving this goal:

- The US must continue to develop the Space Station, OMV/OTV, a heavy lift booster, and NASP, with logisticians deeply involved in the design process.
- The Air Force must establish standardization requirements and have the commitment of all the space players to use them.
- Logisticians must continue to refine logistics modeling techniques and emphasize logistics up front in the design process, keying on satellite maintainability and servicing alternatives.
- NASA must attempt to schedule more on-orbit standardization and maintenance demonstrations to provide the acid test that principles, concepts, and designs are practical for use in space.
- The Air Force must expand its reservoir of space logisticians. With the evolution of logistics in space, we need more than the small cadre of logisticians now available to work the acquisition and support of space systems.

The space frontier is limited only by our imagination. People involved with space today exhibit the same creativity and innovation as the creators of Buck Rogers. Logisticians are duty bound to be a part of this new frontier.

Notes

[1] Baird, Mellon C. *Meeting the Space Command Challenge* (speech delivered to the Space Operations Workshop, November 5, 1985).
[2] Roland, Alex. "The Shuttle—Triumph or Turkey?" *Discover*, November 1985, p. 48.
[3] Ibid.
[4] Ibid., p. 45.
[5] Covault, Craig. "Shuttle EVA's Utilize Techniques Planned for Space Station Assembly, *Aviation Week and Space Technology*, December 1985, pp. 21-23.
[6] USAF Space Division (AFSC) YM Letter, *Draft SOW/CDRL For the Space Assembly Maintenance and Servicing Study (SAMSS)*, Los Angeles, CA, August 8, 1985.
[7] Reagan, Ronald. *The President's Strategic Defense Initiative*, U.S. Government Printing Office, January 1985.

Education and the Space Program Logistician

Air Force space programs offer rich opportunities for people skilled in the logistics specialties. But aspiring space logisticians cannot make a true contribution unless they can communicate with space system engineers in their language and with their tools. This does not necessarily demand a degree in orbital mechanics or fluid dynamics, but understanding the environment in which space systems operate and the basic concepts of orbital physics can provide a crucial degree of credibility. The United States has been launching and supporting space systems for 30 years and has the most reliable and highest quality satellites in the world. With this record, logisticians are not likely to easily convince the space community of the value of support planning using only undocumented, unsubstantiated rhetoric or emotion. But reasoned, practical, informed discussion between logisticians and the space community builds the kind of credibility that *can* impact the space community.

Credibility starts with learning. This comes from reading the trade journals; reading and understanding basic space publications like the *Air University Space Handbook* (AU-18); reading from the bibliography on space provided in this issue of the *Journal;* and going to the base library to research current books and articles on the subject. Logisticians do not have a great tradition of supporting space systems so they have to start from a much smaller base than in the aircraft world. That base must be built upon credibility. A credible logistician can be defined as an educated, knowledgeable, empathic individual capable of communicating reasoned, practical support concepts.

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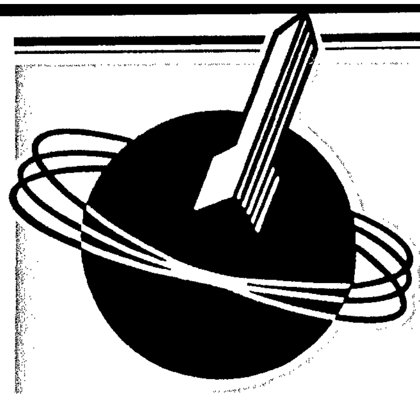

Supportability: A Strategic Defense Initiative Research Imperative

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"Did you write that letter on SDI supportability issues? Are you out of your mind?"

That was the reaction of a senior scientist in the DOD Strategic Defense Initiative Organization (SDIO) when he read a major program policy just published on supportability research—and he was quite serious. His feeling was like that of many others who tend to believe that program managers worry too soon about things like logistics, facilities, and maintenance concepts.

"It's a bit like Ford deciding what color paint it wants for a new line of cars when it hasn't even developed the engine yet," the scientist reasoned.

This point of view can cause eventual havoc for a program, and it is prevalent enough to merit real concern. To his great credit, the individual who said this eventually conceded that our approach might be correct if it were aimed at "getting the issues on the table." Nonetheless, the experience reinforces the following questions:

(1) How important is it to consider supportability at the front end of a program?

(2) How do we properly account for early forces which may eventually drive a program's success or failure?

(3) *When* is the right time for logistical input, and *how much* is right in a research program?

For the SDI, the right time is *now*. The SDI is this nation's extensive research program to investigate technologies which would make possible a defense against ballistic missiles. The aim of the program is to provide a technological and programmatic basis for a decision in the early 1990s on whether to proceed with full-scale development of a ballistic missile defense system. Already, senior program managers have made several far-reaching decisions within both the SDI organization and the Services to assure that, in addition to the "hard" technology matters, support issues relating to the various defense architectures would be considered in conjunction with other program research as it occurs. Further, the space logistics community has established a strategy through which to maintain a continual presence in the development cycle.

Early Commitments

Early in the conceptual planning stage, Brigadier General Robert Rankine (dual-hatted as Special Assistant for SDI on the Air Staff and Deputy for SDI on the Air Force Systems Command staff—AF/RD-D and AFSC/CV-D) was instrumental in assuring that "space logistics" would be a vital concern in the then-embryonic SDI program. By maintaining this essential element be included, and by combining it with a major long-term logistics function—space transportation—he assured there would be a place for logistics "at the table" when it came to establishing overall priorities, program elements, and the work package directives which provide the basis for programmatic direction and funding in the SDI program.

Colonel George Hess, Director of the SDIO Survivability, Lethality, and Key Technologies (SLKT) Office, is responsible for, among other things, the space transportation and support functions. Colonel Hess was equally firm in his belief that logistics would play a significant role in the capability of whatever SDI system might result from the extensive SDI research and technology verification program. By initiating coverage within the SLKT element (with the space transportation and support program initially being called *space logistics*), a firm basis was established for the supportability and logistics integration program, now an integral part of the SDI research effort.

However, space transportation and support (to and within space) are not the sum and substance of SDI logistics concerns. Logistics integration for the SDI is essentially a horizontal organizational function which must provide for a systematic analysis of supportability requirements and opportunities across *all* elements of the SDI, and develop a research program to provide the support capabilities required by evolving architectures.

"The space logistics community has established a strategy through which to maintain a continual presence in the development cycle."

It soon became apparent that a dedicated supportability and logistics function had to be established within the SDI. The position of Assistant Director for Logistics Integration was created within the SDIO Systems Office to tie together a wide variety of logistics disciplines across a broad group of potential system applications. Through this position, contacts were established with offices having supportability expertise. Interaction with NASA and the Air Force was expanded, including the Air Staff, Air Force Logistics Command (AFLC), and AFSC. Meetings were held with the US Army Strategic Defense Command (Crystal City and Huntsville), the Army Materiel Command, and Department of the Army staff offices, as well as with the Special Assistant for SDI within the Office of the Chief of Naval Operations and the Office of the

Secretary of Defense (OSD) Weapons Support Improvement Group. This was the beginning of a network with significant expertise and potential to influence SDI systems research; technology verification; and, where applicable, system design.

Developing a Logistics Strategy

It is helpful to refer to a February 1985 logistics strategy paper developed at an interservice logistics meeting on SDI at the Space Division (Los Angeles AFS). First, the group affirmed the need to establish a credible, productive logistics *presence* within the space technology, development, and management organizations responsible for SDI. Second, logisticians must position themselves to conduct analyses to *scope and define* support requirements, options, and associated risks for near-, mid-, and far-term systems development and technology programs. Third, they must assure application of logistics expertise to SDI *systems design* in concert with, and based upon, established or evolving operational concepts. Finally, they must aggressively advocate and pursue development of logistics *technologies* to improve SDI capability and affordability. These strategies formed the basis for the significant progress made during 1985 in establishing logistics integration on the SDI program.

"Logisticians must minimize the bureaucratic overhead that so often seems to accompany logistics."

Lieutenant General James A. Abrahamson, Director of the SDI Organization (SDIO), has maintained from the beginning that logistics and support will be critical for the SDI. Should it reach full-scale development, production, and deployment, an SDI system would have to be extremely capable. It would have to operate reliably over long periods of standby service in the demanding and hostile conditions of space, as well as in the equally demanding support scenarios typical of complex ground-based missile, radar, and support aircraft systems. General Abrahamson wants his research people to "think reliability, maintainability, and availability" for potential SDI systems because these bring with them the essential overall system capability. At the same time, though, logisticians must minimize the bureaucratic overhead that so often seems to accompany logistics.

Program affordability is a key issue for the SDI. The budgeted costs of *just the research* will run into tens of billions of dollars. Costs for developing and producing a responsive system which could protect the US from Soviet ballistic missiles and reentry vehicles would exceed that by a large measure. And the operations and maintenance costs for the longer term would likely be even greater.

Yet, the dollar value against which supportability has its leverage is larger than any program undertaken to date by the US. Leverage is crucial to an understanding of logistics investment strategies. Research and development (R&D) managers often acknowledge long-term program needs, but immediate demands and problems are legendary in their ability to sap away needed funding and program priority, even when relatively small front-end dollar amounts for support could result in major conceptual reassessment and design analysis for support. Flexibility evaporates quickly as time passes and a program moves through the preconcept and concept validation stages. Ultimately, logisticians and program management can only *react* to problems and then usually with inadequate funding and insufficient lead times to fix mistakes that have been inadvertently designed into the system.

SDI Support Research Policy

How is SDI coping with these opportunities? In addition to having the crucial support of program management, several major activities are proceeding rapidly but with deliberate care.

On 15 October 1985, Lt General Abrahamson signed the *SDI Supportability Research Policy*. This cornerstone document is the basis for assuring that critical support capabilities will be available when needed. The policy provides first and foremost that supportability and logistics will be considered in an appropriate manner for a research program. Where logistics capabilities are available within the Services, and existing support technologies can be seen as adequate even for the extensive demands of SDI scenarios, those elements can be carefully set aside with an understanding of the assumptions which permit such conclusions. On the other hand, some SDI enabling technologies will almost certainly stress our ability to provide adequate maintenance, transportation, data, training, facilities, or other system support elements. These technologies must be identified and the driving forces behind their concept or design approaches isolated so either they can be properly reacted to early—while we have time for support research—*or* their designs can be moved in the direction of being more supportable simply because tradeoffs are being performed within the *total* trade space. Either way, considering *all* trade parameters is immensely important, especially for SDI.

The *Supportability Research Policy* requires support plans for individual programs as well as an integrated support plan for the entire SDI program. It provides for logistic support analysis (LSA) to be the process linking stated and derived support requirements to system designs. Application of LSA on the SDI is being heavily tailored to consider the research nature of the program and the diversity of possible system solutions to the problem. In addition, the policy addresses the following specific elements as examples of *high payoff* support during the front-end conceptual period.

Standardization
Early Development of Maintenance Concepts
Reliability, Maintainability, and Availability
Emphasis on Manufacturing Methods/Producibility
Application of Computer Aided Design, Manufacture, Support, and Engineering
Manpower, Personnel, and Training
Assessment of Logistics Technologies
Use of On-Orbit Servicing
Early Consideration of Technical Information Needs and Approaches
Logistics Information Management, Data Collection, and Analysis
Ground Processing/Turnaround Analysis
Computer Resources and Software Support
Support Equipment Considerations
Transportation/Transportability
Basing, Facility, and Environmental Assessment and Planning
Use of Service-Related Supportability Teams
Use of Government/Industry Expert Panels

How these elements can and should be applied to the SDI will be addressed in increasing detail by contract effort and

organic logistics analyses, by both the SDI organization and the Service organizations implementing the policy.

The *Supportability Research Policy* establishes the basis for an SDI logistics infrastructure—the logisticians, engineers, technical managers, and others who have the necessary background to assist in architectural analysis, conceptual design, and synthesis of a support structure which will consider the issues outlined. It provides for an Integrated Support Working Group, which will be the basis for routine inter- and intra-program communications and review of supportability issues and approaches. It establishes the need for additional work package directives to specifically address the *integration* of logistics concerns across the diverse program elements and projects which make up the SDI. But most of all, it establishes program level support *from the top* to assure that SDI programs will consider logistics as an element in system level concept and design trades. It provides the basis for using supportability as an SDI concept and design yardstick equal with cost, schedule, or performance.

To help carry out this policy, the SDIO is employing several significant contracts. The first is a two-year study to develop methodology for definition, analysis, and integration of support functions and requirements associated with evolving SDI designs. This effort will include LSA at the system level and will emphasize proper performance of tradeoffs across the entire program and against all major system variables. A second contract involves development of an SDI *logistics technologies roadmap and investment plan.* This plan will provide an assessment of the specific technology areas in which logistics-related R&D investment will be necessary and have high payback potential. On the basis of this study, resources will be allocated to areas where SDI logistics support will face new and difficult technical challenges. These contracts are SDI-wide efforts which will affect all elements of the program.

Simultaneously, the Air Force (Space Division/Los Angeles) and the Army (Strategic Defense Command/Huntsville) have been funded to study related but more specific logistics problems. These efforts will be similar in many ways and will provide inputs to both system-level studies. However, each service will also be studying logistics problems and opportunities unique to its own organizations, systems, and special environments. Much has been done, but a long list of technical research and management opportunities remain. The *Supportability Research Policy* is the departure point for a wide range of effort within the SDIO, the Services, involved agencies, and contractors. It is the opening round in the SDI research program effort to assure that whatever US strategic defense systems might someday be fielded as elements of a ballistic missile defense are supportable—and therefore affordable and effective.

What Lies Ahead

Considerable implementation work lies ahead for the SDIO and involved service and agency organizations as they carry out this program direction. Highly qualified, motivated people will be sought out to spearhead the effort. It will be a formidable job to develop and refine essential models and appropriate analytical capabilities, perform required analyses (both internally within the government and contractually), and provide realistic and credible inputs to the concept and design development process. But, now that the essential basis for logistics in the SDI has been established, it is time to produce.

Logisticians Needed

Space System Support—the Wave of the Future

Like the Marines, the Air Force space logistics community needs a few good men and women, both military and civil service, to start developing the space support concepts and systems for the space force of the next decade and century. Opportunities await interested logisticians at many different locations:

(1) All the support AFSCs—particularly 66XX, 27XX, 28XX, 40XX and 49XX—are needed at the Air Force Space Division in Los Angeles and the Electronic Systems Division in Boston.

(2) The Air Force Space Command has five to ten positions at its Colorado Springs headquarters.

(3) The Air Force Logistics Command is working on concepts which will help support space systems in the future.

(4) The Sacramento Air Logistics Center is establishing a small cadre to develop depot level support techniques.

A word of caution is in order, though—it might be misguided to focus on being the "first loggie in space." Most, if not all, of the work being done is in the far front end of the space program. The work is very conceptual and acquisition intensive, but also vital to the well being of the nation.

Logisticians interested in applying for, or learning about, positions involved in developing the support structure for our nation's future defense should send a resume to: the Air Force Acquisition Logistics Center, (AFALC/OP), WPAFB OH 45433, Attn: Mr. Owen; Space Division (SD/AL), PO Box 92960, WPC, Los Angeles CA 90009-2960, Attn: Mr. Richman; or Electronic Systems Division (ESD/AL), Hanscom AFB MA 01731-5000, Attn: Mr. Bleau.

Lt Col George J. Sawaya
SDI Logistics Integration, Air Force Programs
Air Force Space Division

"Air Force logistics must shrink, by design and direction, in its consumption of total Air Force resources."

General Earl T. O'Loughlin
Commander, Air Force Logistics Command

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USAF Logistics Policy Insight

Supply System Security

Recent events have heightened concern over the security of assets within the supply system. While the AF has devoted a great deal of time and effort toward protecting pilferable items (tools, flashlight batteries, watches, and automotive parts), the same emphasis has not been extended toward weapon system parts. Air Force people all along the supply pipeline must be alert to the possibility of individuals stealing weapon system parts in order to sell them to foreign sources. An effective approach is for *Base Resource Protection Committees* to include protection of weapon system parts as key portions of their agendas. Locking critical parts in vaults would be unwise and inhibit our daily production; instead, individuals should take prudent measures to minimize opportunities for theft. The Air Force IG is now in the process of finalizing a report on the security of the supply system. From that report, the AF will initiate a number of actions to improve security. There will be more to follow, but the time to start working the security issue is now.

Stress Screening

On 6 January 1986, the Vice Chief of Staff signed R&M Policy Letter #1 on *R&M 2000* Environmental Stress Screening (ESS). ESS increases the reliability of electronic equipment by identifying parts problems, poor workmanship, and process breakdowns in the factory, not the field. This policy letter establishes general guidelines for ESS and requires the acquisition commands to implement *R&M 2000* ESS on all acquisitions of electronic equipment and components as soon as practicable, but not later than FY87 procurements. Air Force Logistics Command (AFLC) was tasked to implement a pilot *R&M 2000* ESS program by December 1986 with a full *R&M 2000* ESS capability by FY89. Air Force Systems Command (AFSC) is responsible for incorporating the *R&M 2000* ESS guidelines and a procedure to assess defect rates in electronic parts into a military handbook by June 1986.

Guard and Reserve Equipment Priorities

Congress directed in the FY 1982 Authorization Act that the Department of Defense (DOD) annually submit a report on the status of equipment in the Guard and Reserve. The report assesses the current status of equipage in the reserve components and presents a series of detailed tables which set forth the active service plans for distribution of equipment to the components. Congress continues to expand the data requirements and, for the report due 15 February 1986, required data on mobilization requirements with time phasing in 30-day increments. The mobilization data is intended to assist in prioritizing what will be funded in a constrained budget environment. The interest of Congress in the equipage of the reserve components, and the use to which the report is put, are illustrated by the fact that Congress continues to appropriate funds directly to the Guard and Reserve components to purchase equipment.

Revised Construction Regulation

A revised AFR 89-1, *Design and Construction Management,* will soon be released for distribution. The revised AFR 89-1 provides basic guidelines for design and construction management of all Air Force and Air Force Reserve projects except Family Housing. It also encourages professionalism throughout the engineering and services community and allows maximum management flexibility by the MAJCOMs. This approach commits the MAJCOM DEs (civil engineering) to develop a supplemental regulation for execution of design and construction within their commands, and requires HQ USAF/LEEC to issue annual design and construction guidance with the most recent congressional changes.

Munitions Storage Initiatives

RIVET AMMO is a DCS/Logistics and Engineering (AF/LE) initiative to improve combat readiness by increasing munitions storage overseas at the points of intended use. Construction of munitions storage facilities has not kept pace with increasing war reserve materiel (WRM) requirements and inventories. This has resulted in an increased malpositioning of munitions at overseas central storage areas and stateside depots. The goal of RIVET AMMO is to develop a comprehensive out-year munitions storage roadmap for all MAJCOMs. Specific objectives are to prioritize and advocate initiatives to improve munitions storage, such as insensitive high explosives, mechanical diverters, new storage techniques, and revised quantity distance criteria, and to advocate and support funding for munitions storage construction.

Revised Servicing Ground Rules

A completely revised TO 00-25-172, *Ground Servicing of Aircraft and Static Grounding/Bonding,* should be available for distribution to the field in the future. Rewritten during an Air Force-wide conference in November 1985, the new technical order has been restructured to enhance readability and resolve long-standing problems with organizations. In addition, the rewrite includes a number of policy changes of interest to both fuels and aircraft maintenance personnel involved in servicing operations.

Shelf-Life Extensions

No procedures currently exist within DOD to advise users when the life of a shelf-life item has been extended by a depot. AFLC has recently developed and successfully tested a new procedure for reporting shelf-life changes. HQ AFLC/MMM is now developing procedures for Air Force-wide implementation. When implemented, notification to all units will be made through the Stock Number User Directory (SNUD). Pending use of the SNUD, changes will be forwarded to each MAJCOM LGS (Directorate of Supply) by microfiche. The MAJCOM LGS will be responsible for distributing the information to the bases.

Portamod Acquisition Guidance

Congress, in a report accompanying the FY 1896 Military Construction Appropriations Bill and the Appropriations Conference Report, has issued new policy regarding portamods. Beginning with the FY 1987 military construction program (MCP), portamods will no longer be acquired from procurement funds with supporting features identified as an MCP line item. Instead, the costs of the structure and supporting features of construction will be combined into one line item in the military construction bill. The committees based this policy on the definition of a military construction project contained in 10 United States Code, Section 2801. According to the code, a military construction project includes "all military construction work...necessary to produce a complete and usable facility...." This new policy applies to all US installations worldwide as well as facilities at which there is a US presence. Congress funded $1,700,000 requested for portamod support projects by the Air Force in FY 1986.

Deploying Tactical Shelters

Within the next five years, the Air Force expects to have an inventory of 1,100 tactical shelters, while the DOD will have nearly 15,000 overall. The shelters solve many facility related problems (major users include avionics intermediate shops, medics, airlift control elements, and intelligence functions), but their size creates several challenges to the Defense Transportation System. One challenge for shelter users is to identify the appropriate transportation system to move their shelters from the ground at home base, through the airlift or sealift system, and back onto the ground at the deployment location. If no plan exists for transferring shelters through this system, there is a big hole in a unit's shelter deployment scheme. Users are responsible for a part of the movement. The Military Airlift Command, Military Traffic Management Command, Military Sealift Command, and overseas commanders share the remaining responsibility, but they cannot do their job unless users identify their movement requirements to them through unit/MAJCOM mobility and transportation offices.

Mobility Bag Storage

Revision of the supply portion of AFM 86-2, *Standard Facility Requirements,* has been completed. Mobility bag storage is recognized as an additive requirement. Responsibility for mobility bag storage is assigned to the Chief of Supply; however, bags can be issued to individuals for storage. Maximum warehouse stacking heights must be used, and mezzanine space must be included in the available area. Additional space is authorized if war readiness spares kits (WRSKs) are stored on 463L pallets. These changes were published by joint HQ USAF/LEYS/LEEE/LEXP messages, 221752Z Mar 85 and 261835Z Jul 84. AF/LEEE (Engineering Division) will include these policies in its revisions to AFM 86-2.

Base-Level Funding Changes

The Spring 1985 *AFJL USAF Logistics Policy Insights* noted a tri-service proposal to fund Base Procured Investment Equipment (BPIE) with Operations and Maintenance (O&M) rather than procurement dollars and eliminate the $3000 dollar threshold. Congress has now acted on this proposal. Unfortunately, BPIE will continue to be funded with procurement dollars. Favorably, however, the threshold for FY86 BPIE (except medical-dental equipment) has been raised to $5000. The medical-dental equipment threshold will be $5000 effective in FY87. While this change does not provide the ultimate relief to local commanders, it does provide additional flexibility to make cost-effective decisions in spending O&M money while retaining control over major items of equipment.

CEMAS Approval

HQ USAF/LEE/LEY/RDC approved the Civil Engineering Materiel Acquisition System (CEMAS) as the new automated supply support system for base civil engineers. CEMAS has been successfully tested at Tinker AFB OK and Kirtland AFB NM, with materiel response times appreciably better than current systems. Total automation of all materiel transactions, including complete asset visibility and audit trails, will greatly enhance materiel support. Interfaces, documentation, training, and other program requirements are currently being staffed, with worldwide implementation conversion scheduled to begin in late FY86. The conversion will take approximately three years to complete.

Mandated Energy Reductions

Recent guidance from OSD requires that new facilities designed between FY 1986 and 1995 consume 10% less energy than those designed in FY 1985. This means the Energy Budget Figures (EBFs) for new facilities, which have been standard Air Force policy since 1979, will now be reduced by 10%. EBFs are energy figures in KBTU/SF/YR for building space heating, cooling, ventilating, lighting, and heating domestic hot water. This guidance is being disseminated by AF/LEEE Engineering Technical Letter 86-1, Energy Budget Figures. This new EBF is achievable since passive solar techniques (daylighting, atriums, sunspaces, thermal mass storage, etc.) have a potential for large energy savings. The private sector estimates that daylighting alone has a potential of 30% to 70% savings in electric lighting costs.

LOGDET Accuracy

The sole source of Air Force data which identifies the movement requirements (i.e., passengers and cargo tonnage) for operation plans is the Air Force Logistics Detail (LOGDET). LOGDET is developed by pilot units and reported quarterly to their major commands (MAJCOMs). Since the accuracy of LOGDET directly affects the validity of strategic airlift requirements in JCS-approved war plans, and therefore impacts AF readiness, the Directorate of Logistics Plans and Programs (AF/LEX) is placing increased emphasis on the development and review of this data. MAJCOMs have been requested to ensure LOGDET receives emphasis at all levels of command from the individual units through submissions to HQ USAF. The Air National Guard hosted, and the Air Staff conducted, a Worldwide Conference at Denver to provide added impetus to this initiative. Additionally, a pamphlet should be in the field shortly to provide hard copy guidance to Air Force units developing or using LOGDET.

User-Developed Software for Air Force Microcomputers

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No other development in the history of computer technology even comes close to matching the impact of the microcomputer on the way in which organizations do business. (3:41)

Introduction

Microcomputers are quickly becoming indispensable tools in Air Force logistics. These versatile machines reduce the drudgery associated with manual record-keeping and analysis, enabling logisticians to spend a larger percentage of their time performing tasks that directly support the mission.

We are just beginning to realize how much microcomputers can help us work more efficiently and faster. The key to their utility is tied to the nature of information itself. Information is a logistician's most important resource, but its value is so time-sensitive that information which is critical at one point in time may be worthless only a few hours later. Microcomputers help increase productivity and cut costs by making timely, accurate information available where needed most—on the flight line and in the shops where the day-to-day work of logistics is performed. (5:8)

This paper outlines the key issues affecting the acquisition and use of microcomputers in Air Force logistics. It discusses current methods for obtaining microcomputer hardware and software, focusing on sources of software, with particular emphasis on end-user development. (For the purpose of this paper, *end-users* are non-programmers whose primary responsibilities are in one of the core logistics areas, such as transportation, supply, maintenance, etc.)

The Hardware Boom

Microcomputer acquisitions have increased tremendously since 1983, when the Air Force and Navy jointly developed a requirements contract to streamline the ordering process and make it easier for individual units to obtain microcomputers. By September 1985, Air Force units had purchased over 27,000 Zenith Z-100s. A follow-on contract to be signed this year will allow the two services to purchase up to 60,000 more microcomputers over the next few years. (6:14,10)

This acquisition strategy has several advantages. First, it allows units to obtain computers quickly and with a minimum of paperwork. Second, it gives the Air Force and Navy the leverage needed to negotiate a very good price on the computers because of the large number of purchases forecast. Finally, it results in the Zenith Z-100 becoming a hardware standard throughout much of the Air Force, simplifying maintenance, training, and programming support. In the long run, establishing hardware standards is extremely important. Their absence invites a proliferation of different computer architectures and operating systems which can complicate support tremendously and result in significant interfacing problems. (11) Units only buy the hardware once, but they must provide maintenance, training, and programming support indefinitely. Realistic hardware standards must be developed and enforced.

The Software Connection

Technological advances have made the microcomputer a powerful tool with remarkable capabilities, but it is software that makes microcomputers useful in solving practical logistics problems. Purchasing microcomputers in large quantities has created a huge demand for software. Traditional Air Force software developers already have a large backlog of modifications and enhancements to existing mainframe computer systems and are planning to develop several new systems. With most of their resources already committed, they are unable to satisfy the demand for microcomputer software. (1,8) As a result, the Air Force has been forced to re-examine its software acquisition strategy and look for new ways to obtain and develop software.

At present, there are three main sources of microcomputer software for Air Force logisticians: software programs developed by the Air Force's Standard Information Systems Center (SISC), Gunter AFS AL; general-purpose commercial software developed by private companies; and user-developed software. The last two options are becoming increasingly important. A Program Management Directive (PMD), issued 7 October 1985, established the Information Systems Technology Application Program (ISTAP) which is charged with modernizing software development methods in the Air Force. ISTAP advocates the use of commercial software, programming aids, and end-user development to facilitate software production. If ISTAP achieves its goals, after 1989, 50% of all software developed in the Air Force will be developed by end-users. (8)

"After 1989, 50% of all software developed in the Air Force will be developed by end-users."

Each of the three sources of software will be discussed, but particular emphasis will be placed on the ramifications of end-user development, since it represents a radical change in Air Force software development methods.

Standard Air Force systems

Standard systems for logistics are developed at SISC. In view of the Center's responsibility for developing and maintaining "standard" base-level systems, it uses a highly structured process to define and analyze requirements systematically, and design, develop, and implement computer systems. This process is lengthy and involves a good deal of overhead, but it is a necessary part of multimillion dollar mainframe development efforts. However, the overhead associated with these processes makes it economically infeasible to take on small, low priority projects. (7) This approach is best suited to developing large Air Force unique programs that perform highly specialized functions and is not appropriate for hundreds of small microcomputer programs directed toward productivity increases and cost savings. For example, the student scheduling system and internal accounting efforts initiated by the Air Force Combat Ammunition Center (AFCOMAC), Sierra Army Depot, Herlong CA, fit into the latter category.

Commercial software

Commercially developed general-purpose programs for word processing, data base management, and spreadsheet analysis can satisfy the needs of many end-users. Using commercial software has several key advantages. Since the programs are general purpose in nature, they are easy to use and flexible enough to accommodate a wide range of needs. Individuals can use the same program for a variety of purposes without having to learn a new set of commands each time they begin a new task. Most commercial programs are inexpensive when compared with the cost of developing a program tailored to perform a specific function, and they can be obtained much more quickly. Finally, many commercial programs have become accepted as *de facto* standards. As a result, a large body of knowledge about how to get the most out of programs like WordStar®, dBase II®, and LOTUS 1-2-3® exists. (5)

End-user development

End-user development provides an alternative to traditional methods of software development. Some end-users write programs in conventional computer languages like COBOL, FORTRAN, or BASIC, but the trend is to write programs in the command languages built into general-purpose data base management programs like dBase II® or Condor®. (5) This approach simplifies the program development process because the general-purpose software automatically takes care of physical storage and most file management functions. With the hard part of programming out of the way, users can concentrate on defining the problem and extracting the information needed to solve it. Within a short time, a beginner can develop useful programs in one of these powerful command languages. (2, 9)

Characteristics of User-Developed Software

Time, Cost, and Versatility. End-user development sidesteps many of the problems associated with traditional Air Force software development methods. Compromises between requirements and the cost (time and effort) of software development can be made by the person who will have to live with the finished program. The iterative approach users employ in developing their own programs also has advantages. The user refines his requirements and improves his program one step at a time. This step-by-step, problem-oriented approach toward programming often results in modular programs which are easy to debug and modify later. In

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Information Systems Technology Application Program

Statement of Operational Need and Technical Objectives:

The primary objectives of this program are (1) to improve operational mission capability and effectiveness by quickly providing correct, reliable, tailored information to commanders and other decision makers who command, control, and manage the forces, and (2) to facilitate the reductions in manpower in the information systems and functional areas through the application of modern information technology. The goals of the program are outlined below for the two primary segments which are now planned:

Programmer Productivity:

- Deliver higher quality software faster in support of priority Air Force missions.
- Incorporate modern software development tools and techniques into virtually all Air Force information systems development and support activities.
- Achieve a validated improvement of at least 10% in programmer/analyst productivity.
- Reduce programmer/analyst manpower by an appropriate number of authorizations as a result of increased productivity.

End-User Productivity:

- Allow the decision maker or immediate staff to rapidly create or modify software to provide information needed on short notice.
- Validate the potential of modern "user-friendly" information technology and software development tools to allow end-users to develop their applications with a minimum of information specialist assistance and major productivity improvements and associated manpower reductions in end-user functions.
- If justified by prototype demonstrations, introduce modern "user-friendly" information technology and software development tools and techniques to a wide range of high pay-off functional applications to increase productivity and facilitate manpower reductions along with improvement mission effectiveness.
- Through the introduction of new technology, training, and technical support, reduce the role of information systems (SI) specialists in the information systems development process. Achieve the goals for refocusing Air Force's approach to information systems development specified below:

Software Development Approach	Current (FY85)	(FY88)	Goals (FY89)	(FY90)
User developed without major SI assistance	5%	15%	30%	50%
User developed with SI assistance using modern techniques	5%	7%	10%	15%
Developed by SI personnel	90%	78%	60%	35%

Source: PMD 5257(1)/PE 91212F, 7 October 1985

— Condor is a registered trademark of Condor Computer Corporation.
— WordStar is a registered trademark of MicroPro International Corporation.
— dBASEII is a trademark of Ashton-Tate.
— LOTUS 1-2-3 is a trademark of Lotus Development Corporation.

addition, this approach allows users to begin working on the new program almost immediately and (in many cases) complete it within a few hours. (5)

Direct Applicability. Because end-users usually understand the problems they are trying to solve, many of the programs they have developed are extremely useful:

- Alaskan Air Command (HQ AAC/LGT) developed a BASIC program to track the flow of transport airlift during its annual "Cool Barge" remote site replenishment exercise.
- Space Command (HQ SPACECOM/LGM) developed a munitions data base program using LOTUS 1-2-3 which provides up-to-the-minute aircraft munitions load status information.
- Military Airlift Command (HQ MAC/LGT) developed and distributed two excellent dBase II programs to manage inbound and outbound personal property shipments for base traffic management offices.

Many more examples could be added to the list. The point is that end-user development has a tremendous potential and should be taken seriously.

Built-in Limitations. But, despite its advantages, end-user development will never be the answer to all programming problems. While end-user development works well on small-to-medium size programs designed for stand-alone operation, some programs are simply too big or too complicated to be developed by end-users. End-users cannot be expected to use the same rigorous approach to software development as full-time professional programmers. This raises troublesome questions about program verification and computational efficiency. (5)

Documentation Problems. Users typically place little importance on developing program documentation. This is understandable since writing manuals for programmers and users is not directly related to solving the current problem. (5) Unfortunately, in organizations with high rates of turnover, like the Air Force, documentation is a practical necessity. Without it the maintenance of software is difficult or impossible. Once the program developer leaves, it may be easier to rewrite the program than modify it, unless the program code is sufficiently documented.(5) Even if documentation standards for end-user developed software were established, enforcing them would be virtually impossible.

Lack of Standardization and Economies of Scale. Duplication of effort and lack of standardization also cause problems. It is not productive for ten different units to develop ten different versions of the same report. If that happens, the Air Force has invested ten times the man-hours it should have taken to develop the program. Also, we probably have ten programs incompatible with each other. The Air Force Logistics Management Center's (AFLMC) Small Computer Applications for Logistics and Engineering (SCALE) project helps to mitigate these problems by providing a central repository for information on microcomputer programs developed by logisticians throughout the Air Force. Each entry in SCALE describes a program and provides information on what it does, the equipment and software needed to run it, and how to obtain the actual program. At present the SCALE data base contains nearly 100 programs.

Conclusions

Although some potential problems are associated with end-user development, its advantages far outweigh its disadvantages. This method of software production has tremendous potential because the key to developing a program—any program—is understanding the problem. No one is in a better position to do that than the person who has to deal with it every day. To take advantage of this, we must provide end-users with adequate hardware, software, and training. Training is absolutely essential. Whether we expect end-users to develop their own software, or just use what is already available, the importance of training cannot be overstated. (9)

Easy-to-use microcomputers with powerful software are revolutionizing the way we work. They have already led to significant cost savings and productivity increases, with more to come. End-users are accomplishing some tasks that have traditionally been the responsibility of professional programmers, and they will soon assume an even larger role in the development of applications programs. Logisticians are beginning to see computers for what they are—tools for manipulating information.(1) Improved information flow will lead to greater efficiency as users finally gain control of their most important resource—information. According to Peter Drucker: "If the computer doesn't enable us to simplify our organizations, it's being abused." (4:174)

Small Computer Applications for Logistics and Engineering

The Deputy Chief of Staff for Logistics, HQ USAF, has appointed the Air Force Logistics Management Center (AFLMC) the focal point for small computer applications for logistics and engineering. The Center provides technical assistance to logistics personnel operating small computers throughout the Air Force and maintains a controlled repository containing descriptions of logistics application programs submitted by various organizations. The programs are in document form and are readily accessible through keyword search. The data base is on an IBM 4331 and has a dial-up access.

Information concerning computer access and use of the data base is contained in a *SCALE User's Guide*. For users not having access to a computer, a *Software Catalog* provides a hard-copy listing of the applications. These publications and further information are available from AFLMC/LGY (Capt Tom James/Lt Kelly Owens), Gunter AFS AL 36114-6693 (AUTOVON: 446-3514/4524).

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Using Dyna-METRIC To Structure Mission Support Kits

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Several articles have been published detailing the internal functions, outputs, and limitations of the Dyna-METRIC model.[1] Other articles have dealt with evaluating Dyna-METRIC output performance information (not mission capable, supply (NMCS) aircraft, number of sorties flown, and total back orders). Each of the articles has enhanced our ability to measure the operational readiness of United States Air Force flying units. This paper offers a practical approach for structuring mission support kits (MSK) for fighter units, thereby improving the operational effectiveness of deployed flying squadrons.

The Need

A growing need exists within operational fighter squadrons to select the proper level of spare parts to accompany aircraft on a deployment. The Dyna-METRIC model can do this. It will select a mix of spare parts that will, with a given confidence level (user specified), meet a given performance goal (also user specified) when flown against a given flying scenario. The flying scenario is the key since Dyna-METRIC assumes demands are a simple Poisson arrival process with mean arrival rate proportional to the flying activity.

Selecting Options

Two substrategies within the Dyna-METRIC model can be employed to select the required component stock: selecting spares to assure each component individually achieves the target NMCS performance goal (disregarding other components), or selecting spares to assure *all* components considered together jointly achieve the target NMCS goal for aircraft as a whole.

In each case, the model uses Palm's Theorem[2] to model the various components' pipeline probability distributions to determine the stock required to meet the NMCS target with the stated confidence level.* Using Dyna-METRIC option 3, this is done considering each item in isolation. In Dyna-METRIC option 4, the model first assures each component achieves the goal individually and then selectively adds additional stock (safety stock), using a technique called marginal analysis, until the convolution of stockout probabilities over all items gives the desired performance.

At this point, we will consider a sample data base of ten F-16 items (Table 1):

NOUN	DEMAND RATE	COST-$	QPA **
Engine	.00590	2,692,000	1
Fire Control Computer	.00403	61,583	1
Radar Antenna	.00542	124,239	1
Radar Transmitter	.00645	85,149	1
Radar Computer	.00373	81,609	1
Digital Signal Processor	.00312	102,353	1
Central Interface Unit	.00370	70,096	1
Hydrazine Tank	.00145	11,095	1
Oxygen Regulator	.00653	830	1
Jet Fuel Starter	.00290	27,130	1

** QPA = Quantity per Aircraft

Table 1.

The data base includes sample items essential to airborne activity (fire control computer, radar components), flight (engine), or safety (oxygen regulator). The table also shows the wide range of unit costs among these items.

Using these items as the range of a sample MSK, we will determine stock requirements for a 12-aircraft deployment for 30 days with each aircraft flying one sortie per day of 1.3 hours duration. We will assume all 12 aircraft are available and fully mission capable (FMC) prior to the deployment. Also, there is no cannibalization of any shop replaceable units (SRUs) contained on the engine or the other nine line replaceable units (LRU), and we are operating from a remote location with the capability only to replace failed LRUs and engines.

If option 3 of Dyna-METRIC is selected, the model will add base stock for one component (LRU) at a time until fewer base aircraft than the target percentage would be degraded (NMCS) due to that part. Suppose we chose a "9%" NMCS target at 85% confidence. The model would add stock to the first component until it was at least 85% confident of causing not more than 9% of the aircraft to be NMCS. Then the process would be repeated for the remaining components.

For our data base, Dyna-METRIC option 3 selected the quantities shown in Table 2.

NOUN	QUANTITY
Engine	3
Fire Control Computer	2
Radar Antenna	3
Radar Transmitter	4
Radar Computer	2
Digital Signal Processor	2
Central Interface Unit	2
Hydrazine Tank	0
Oxygen Regulator	4
Jet Fuel Starter	1

Table 2.

Selecting option 4 would cost effectively add additional stock (LRUs) beyond option 3 levels to assure fewer base

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*Dr. Gordon Crawford delivered a paper at the 1983 Logistics Capability Assessment Symposium (LOGCAS 83), "Disturbing Variations in Demand Rates."[3] It examined excessive variation in empirical demand rates for important aircraft components and discussed possible explanations and the significance concerning capability assessment and requirements determination. There is reason to believe the demand rate variation is greater than that normally used in Dyna-METRIC analysis. Nevertheless, we have applied the standard assumption for this analysis—that the demand process is Poisson with all variance-to-mean ratios set to "1". If the variation is indeed greater than that, the required stock levels would be increased.

aircraft than the target percentage would be degraded when considering all components together. Using the example parameters, option 4 would assure with 85% confidence that, in combination, the components (LRUs) would not violate the 9% NMCS goal. (NOTE: If two parts are independent of each other with part "A" 85% confident of meeting the NMCS goal and part "B" also 85% confident of meeting the goal, the multiplication law of probabilities says the two together will be only 72% (.85 × .85) confident of meeting the goal.)

Table 3 illustrates the quantities that would be purchased under option 4, compared to option 3, using real dollar unit costs in the marginal analysis algorithm:

NOUN	OPTION 3 REAL U.C.$s QUANTITY	OPTION 4 REAL U.C.$s QUANTITY	ADDITIONAL PURCHASES
Engine	3	3	0
Fire Control Computer	2	5	3
Radar Antenna	3	5	2
Radar Transmitter	4	6	2
Radar Computer	2	4	2
Digital Signal Processor	2	4	2
Central Interface Unit	2	4	2
Hydrazine Tank	0	3	3
Oxygen Regulator	4	10	6
Jet Fuel Starter	1	4	3
	OPTION 3	OPTION 4	DIFFERENCE
OVERALL STOCK	23 units	48 units	25 units
EQUIVALENT "COST"	$ 9.45 mil	$ 10.68 mil	$ 1.23 mil
OVERALL CONFIDENCE OF < 9% NMCS	39%	85%	46%

Table 3.

In comparing the results, the overall system under option 3 has only a 39% chance of staying under its NMCS goal. That option should not be used to structure an entire MSK. Also, the required number of engines did not change, but the quantity of oxygen regulators more than doubled. This is to be expected because under marginal analysis (option 4), unit cost tends to drive requirements inversely.

Marginal analysis works this way. We pick a performance measure (for example, NMCS aircraft). To determine which item to allocate the first piece of additional stock, we selectively give it to each item one at a time and record the corresponding reduction in NMCS aircraft associated with having that additional piece of stock. Then we divide this reduction (the change in NMCS) by the item's unit cost. We give the first piece of stock to the item having the greatest reduction in NMCS *per unit cost.* This process would be repeated until the kit performance goal is met. The end result is the lowest priced kit that meets performance goals.

The disadvantage of using marginal analysis is not all parts get equal protection against stockouts. Generally, the lower cost items get plenty of protection (safety stock), and the higher cost items get much less. This may not be a bad policy if management attention can help protect items with little or no safety stock and if actual money were being spent to develop the MSK. However, neither of these conditions is generally true. Mission support kits are generally formed by drawing down from other sources (war readiness spares kits (WRSK), base-level self-sufficiency spares (BLSS), or peacetime operating stock (POS), not by spending money to buy additional assets. Also, on many deployments no repair or resupply is available. Thus, management attention can do little to help protect particular items.

A DYNA-METRIC PRIMER

The options available in running Dyna-METRIC are:

1 Print a warning message when sorties cannot be achieved with a given confidence.
2 Optimally buy centralized intermediate repair facility (CIRF) pipeline stock to achieve a backorder goal.
3 Optimally buy base pipeline stock to achieve a backorder goal.
4 Optimally buy base pipeline stock to achieve an NMCS goal.
5 Buy enough test equipment to cover mean test time demands.
6 Optimize SRU stockage to achieve a backorder goal.
7 Optimize SRU stockage over all SRUs belonging to the same LRU.
8 Generate problem parts list.
9 Print stock levels at each time value (computed).
10 Initialize peacetime pipelines using data read in from file 2.
11 Give performance output based on input stockage.
12 Give performance output based on calculated stockage at each time.
13 Do —not— echo input.
14 Do —not— echo parts input.
15 Generate logical file 8.

Parameters to Options:

Option 1 requires one parameter:
- Confidence level desired for sortie generation

Options 2, 3, 4, 6, and 7 require two parameters:
- Backorder or NMCS target percentage of number of aircraft (integer number)
- Confidence level desired (real number)

Option 8 also requires two parameters:
- Maximum number of problem parts to list (integer number)
- Performance goal in designating problem parts (real number)

Options 11 and 12 require one parameter:
- NMCS target percentage for calculating performance (integer number)

Option 15 requires one parameter:
- Set this to 0 if only the detailed pipeline report is desired. A setting of 1 will generate a very detailed group of reports dealing with matters like the queues for each type of test stand for each day of the scenario.

Options 5, 13, and 14 do not require parameters.

Additional Information:

If Option 4 is on but not Option 3, Option 3 is assumed to be on with the same values as Option 4.

If Option 7 is on but not Option 6, Option 6 is assumed to be on with the same values as Option 7.

Under these conditions, using option 4 with a *constant* unit cost for each component would be a reasonable alternative for structuring Dyna-METRIC to generate the MSK. This would cause marginal analysis to give "equal" safety stock protection to each item. For our sample range of items, and using a nominal constant unit cost of $1, Table 4 shows the mix of items for our MSK:

NOUN	OPTION 4 REAL U.C. $s QUANTITY	OPTION 4 CONSTANT U.C. $s QUANTITY	ADDITIONAL PURCHASES
Engine	3	5	2
Fire Control Computer	5	4	−1
Radar Antenna	5	5	0
Radar Transmitter	6	5	−1
Radar Computer	4	3	−1
Digital Signal Processor	4	3	−1
Central Interface Unit	4	3	−1
Hydrazine Tank	3	2	−1
Oxygen Regulator	10	5	−5
Jet Fuel Starter	4	3	−1
	OPTION 4 REAL U.C. $s	OPTION 4 CONSTANT U.C. $s	DIFFERENCE
OVERALL STOCK	48 units	38 units	−10 units
EQUIVALENT "COST"	$10.68 mil	$15.62 mil	$4.94 mil
OVERALL CONFIDENCE OF < 9% NMCS	85%	85%	NO CHANGE

Table 4.

The $5 million increase is immediately evident. Recall, however, that this is only the associated *inventory* value of the items gathered for the MSK. No actual procurement took place. The benefit of this scheme is it gives equivalent performance with an overall reduction of ten assets from the selection that used real dollar values. More importantly, it gives approximately the same safety stock protection to each component. A major disadvantage, however, is that the engine requirement increased by two (hence the much higher equivalent cost). An increased engine requirement introduces two special concerns—asset availability and airlift capacity. Either could be a limiting factor. If not, these quantities would be appropriate to use in a mission support kit.

If, however, an engine requirement of 5 is not tolerable, alternative schemes will accommodate the constraint. For example, the option 3 level could be used for engines and option 4 for all other quantities. This combination would then be run through the Dyna-METRIC model using the assessment option (option 11) to find the overall system performance. Since Dyna-METRIC assumes independence among LRUs, the new confidence level would be approximately (.85 × .85) = .72 (.85 for the "system" of 9 non-engine parts times the .85 for the engine). Table 5 shows the results of that Dyna-METRIC run.

Option 4 (Constant $1.00 Unit Cost) for Non-Engine Items and Option 3 for Engine

NOUN	QUANTITY
Engine	3
Fire Control Computer	4
Radar Antenna	5
Radar Transmitter	5
Radar Computer	3
Digital Signal Processor	3
Central Interface Unit	3
Hydrazine Tank	2
Oxygen Regulator	5
Jet Fuel Starter	3

EQUIVALENT COST $10.24 mil — OVERALL STOCK 36 units

NO. A/C	TARGET NMCS A/C	PROB OF ≤ 9% NMCS	EXPECTED NMCS A/C	EXPECTED SORTIES	TOTAL BACK ORDERS
12	1	.77	.89	11.11	1.10

Table 5.

Using this MSK, we will be 77% confident of staying below our NMCS target. Is this an acceptable alternative for the squadron commander, given the stated initial goal was 85% confidence? It may be, since it reduced the total number of assets required for the mission support kit, reduced the "equivalent cost" of the MSK by $564,084, and reduced both the storage and airlift requirements. In addition, we have done the following toward meeting our performance goals. First, considering just the engines, three engines meet the required 85% confidence of less than 9% NMCS. Second, the other nine LRUs considered together also meet the 85% confidence level of < 9% NMCS.

Considering all these facts, the squadron commander may be willing to deploy with the Table 5 MSK. If, however, he insists on the higher original system confidence level (85%), the following steps can be taken: First, determine what it would take to construct an MSK that contains only three engines but meets all goals. Proceed by making a Dyna-METRIC assessment run on the engine only, with input stock set to three engines. The output shows on day 30 of the deployment an 88% confidence of having no more than 9% of the fleet NMCS. Next, divide the .88 into the desired system goal of .85. The quotient, .97, is the new confidence level required for the nine non-engine items. The final step is to set up a Dyna-METRIC option 4, constant dollar requirements run for those nine items with target goals of 9% NMCS and 97% confidence. The quantities from that run plus the three engines are then assessed using option 11 (output performance based on input stock) with the results shown in Table 6. Although this MSK meets the overall goal with only three engines, it required several more non-engine units. The 97% confidence is getting into the area of diminishing returns. That is, several more units yield only a little more performance.

Option 4 (Constant Unit Cost at 97% Confidence) for Non-Engine Items and Option 3 for Engine

NOUN	QUANTITY
Engine	3
Fire Control Computer	5
Radar Antenna	6
Radar Transmitter	7
Radar Computer	5
Digital Signal Processor	4
Central Interface Unit	4
Hydrazine Tank	2
Oxygen Regulator	7
Jet Fuel Starter	4

EQUIVALENT COST $10.96 mil — OVERALL STOCK 47 units

NO. A/C	TARGET NMCS A/C	PROB OF ≤ 9% NMCS	EXPECTED NMCS A/C	EXPECTED SORTIES	TOTAL BACK ORDERS
12	1	.86	.54	11.46	.58

Table 6.

Perhaps a more attractive alternative is to increase the number of engines by one (total of four) and use the previous procedures to determine the new confidence goal for an option 4, constant dollar requirements run for the nine non-engine parts. Proceeding as before, we set up an assessment run for engines only. The output shows that four engines give 95% confidence. Dividing .95 into .85 gives a new confidence goal of .89 for the final non-engine requirements run. The quantities from that run are added to the four engines to form the required MSK. That MSK is then confirmed with an option 11 Dyna-METRIC run. Table 7 shows the results. The performance is essentially equivalent to the MSK in Table 6. The Table 7 kit has more protection for the engine, slightly less for the non-engine parts, and requires fewer total spares. The total weight and cube, however, are probably greater due to the additional engine.

Option 4 (Constant Unit Cost at 89% Confidence) for Non-Engine Items and One Additional Engine Above the Option 3 Level

NOUN	QUANTITY
Engine	4
Fire Control Computer	4
Radar Antenna	5
Radar Transmitter	5
Radar Computer	4
Digital Signal Processor	3
Central Interface Unit	4
Hydrazine Tank	2
Oxygen Regulator	5
Jet Fuel Starter	3

EQUIVALENT COST $13.08 mil — OVERALL STOCK 39 units

NO. A/C	TARGET NMCS A/C	PROB OF ≤ 9% NMCS	EXPECTED NMCS A/C	EXPECTED SORTIES	TOTAL BACK ORDERS
12	1	.86	.59	11.41	.68

Table 7.

Final Thoughts

If storage or airlift is the limiting factor for a scenario rather than asset availability or "equivalent cost," each item's actual volume (or weight) could be used in place of the unit cost factor. Using option 4, the model would then apply marginal analysis to build a kit giving the same overall performance while minimizing total kit volume (or weight). Under these circumstances, an item's safety stock would tend to be inversely related to its volume (or weight). No one item's individual confidence level would be lower than the specified goal, and the system as a whole would meet or exceed that same goal. Another alternative would be to use a weighted average of weight and cube or even weight, cube, and "equivalent cost."

Dyna-METRIC is a useful tool for structuring a mission support kit, but it is just that—a resource tool. The wing commander, analyst, and other decision makers ultimately must decide what Dyna-METRIC options, performance goals, and strategy to use in order to best meet the specific scenario confronting them.

Notes

[1]Hillestad, R. "Dyna-METRIC: A Mathematical Model for Capability Assessment and Supply Requirements when Demand, Repair, and Resupply are Nonstationary," Santa Monica, CA: The Rand Corporation, R-2785-AF, 1982.

[2]Crawford, G. B. "Palm's Theorem for Nonstationary Processes," Santa Monica, CA: The Rand Corporation, R-2750-RC, 1981.

[3]Crawford, G. B. "Disturbing Variations in Demand Rates," Santa Monica, CA: The Rand Corporation, WD-1797-AF, 1983.

▶ FROM 29

Harvest Eagle Inventory Management System
Objective: Develop an automated capability to manage and to improve deployment and reconstitution of Harvest Eagle assets.
Maj Rickard, AFLMC/LGX, AUTOVON 446-3365

Statistical Performance Measures
Objective: Relate supply performance measures to operational performance or operational hours to supply performance measures. Use sophisticated statistical techniques to relate supply indicators to operational performance.
Maj Blazer, AFLMC/LGS, AUTOVON 446-4165

F-15 Fault Reporting/Fault Isolation (FR/FI) Test
Objective: Determine, when properly implemented in a newly activated unit, if FR/FI manuals meet their stated objectives: provide pilot/debriefer structured interface for fault description; provide accurate assessment of fault; decrease debriefing time and maintenance time; use spare parts better; and provide quicker turnaround time, less downtime, and greater sortie rate. Determine what problem limitations exist.
Capt Gemas, AFLMC/LGM, AUTOVON 446-4581

Mobility Mini-Exercises
Objective: Develop a guide for mini-exercises so critical mobility areas can be exercised without committing too many base resources and individual problem areas can be evaluated.
SMSgt Petersdorf, AFLMC/LGX, AUTOVON 446-3355

Maintenance Information Needs
Objective: Determine real maintenance data requirements in the context of new data systems being developed. Based on this determination, recommend changes to current and proposed systems to ensure the Air Force collects proper data to facilitate weapon system management at both wholesale and retail levels.
Capt Hayes, AFLMC/LGM, AUTOVON 446-4581

Levels of Vehicle Maintenance
Objective: Formalize a maintenance concept which clearly defines what maintenance tasks should be accomplished at base level versus local contract or depot levels. The maintenance concept should indicate and support requirements for manpower, facilities, funds, equipment, and training to ensure an adequate wartime vehicle maintenance capability.
Capt Dalton, AFLMC/LGT, AUTOVON 446-4464

"In combat, actions taken to drive up the adversary's friction are as vital to success as those taken to minimize your own."

Lt Col Barry D. Watts, The Problem of Friction in War (AU Press, 1984)

CURRENT RESEARCH

Air Force Logistics Management Center - FY85 Program

Periodically, the Logistics Management Center contributes to this portion of the Journal. Our last contribution appeared in the Winter 1985 edition. Many of the projects in that listing have been completed, and we sincerely hope the Air Force Logistics community is more effective because of them.

Cooperative efforts outside the Center have been outstanding. Students and faculty members at Air University and the Air Force Academy provided significant inputs to our projects. Other personnel from MAJCOMs and bases have helped by providing "real world" data, test-bed sites, survey participants, "sounding boards" for new approaches, and key recommendations on better ways to solve logistics problems.

If you are interested in any of these projects, please contact the project officer. If commercial lines are used, dial Area Code 205, 279-plus the last four digits of the AUTOVON number.

1985-86 Projects

Deployable Mobility Execution System (DMES)-Phase II
Objective: Develop the capability to perform interactive load planning on B747, KC-10, and KC-135 aircraft. The experience gained in programming the C-141, C-130, and C-5 will aid in programming these additional aircraft. Also, the Data Systems Design Office (DSDO) has successfully converted DMES to run on the Zenith microcomputer.
Dr. Gage, AFLMC/LGY, AUTOVON 446-3514

Base-Level Reliability and Maintainability (R&M) Improvement Program
Objective: Develop a responsive system to identify and track component/ hardware R&M problems. Recommend solutions to HQ USAF/LE.
Major Lindsey/Capt Albright, AFLMC/LGS/LGM, AUTOVON 446-4165/4581

Interim Deployable Maintenance System
Objective: Develop an Interim Deployable Maintenance System capable of supporting maintenance units in a deployed environment. The system will meet the minimum needs of the user and serve as an interim system until the implementation of the Deployable Core Automated Maintenance System (DCAMS).
Capt Fandre, AFLMC/LGM, AUTOVON 446-4581

Base-Level Contracting Wartime Concepts
Objective: Develop a Concept of Operation (CONOP) for contracting wartime support.
Capt Ferguson, AFLMC/LGC, AUTOVON 446-4085

Capability Assessment Model of Munitions Production (CAMMP)
Objective: Create and demonstrate a simulation model usable at base level to assess munitions production capability from initial receipt to flight-line delivery.
Capt Taylor, AFLMC/LGM, AUTOVON 446-4581

Automated Aerospace Ground Equipment (AGE) Scheduling
Objective: Develop a computer program to automate AGE scheduling. Determine support equipment scheduling requirements. Develop automated scheduling system to meet these requirements. System will serve as prototype for a standard Air Force system to interface with the Core Automated Maintenance System (CAMS).
Maj Moss, AFLMC/LGM, AUTOVON 446-4581

Awaiting Parts (AWP) Enhancement
Objective: Examine the Air Force AWP program to determine if it is providing the best possible supply support to the base-level repair program.
Maj Lindsey, AFLMC/LGS, AUTOVON 446-4165

OPLAN Annex and Unit Type Code (UTC) Data Base
Objective: Develop a microcomputer capability to download annex and UTC Contingency Operations Mobility Planning and Execution System (COMPES) data and tailor the data to produce schedule of events, load lists, mobility control center (MCC) outgoing message traffic, etc.
Capt Grandalski, AFLMC/LGX, AUTOVON 446-3355

Standard Base Supply System (SBSS) Reparable Simulation Capability
Objective: Develop the capability to simulate reparable stockage policy and repair processes.
Maj Blazer, AFLMC/LGS, AUTOVON 446-4165

Upload/Download to Micros
Objective: Provide the capability to download and upload data information efficiently between microcomputers and mainframe computers for the following AFLMC programs: Automated Flying and Maintenance Scheduling (AFAMS); Minimum Essential Engine Tracking System (MEETS); and STATUS. Provide lead application for all AFLMC projects that require interface with Sperry 1100/60 computers.
SMSgt Chambers, AFLMC/LGM, AUTOVON 446-4581

Enhanced Vehicle Out of Commission (VOC) Status Report
Objective: Determine alternative methods for the computation of VOC rates. Develop more comprehensive management indicators to provide true productivity assessment. Establish a fleet status formula to allow more accurate readiness reporting.
Capt Winters-O'Neal, AFLMC/LGT, AUTOVON 446-4464

Wartime Information Requirements for Transportation
Objective: Determine minimum essential information requirements for transportation management which would apply to any theater of operation during a contingency. Determine these information needs for the three primary areas of base-level transportation—vehicle management, vehicle maintenance, and traffic management (traffic and air).
Capt Wasem, AFLMC/LGT, AUTOVON 446-4464

Applying the Manpower Impact Assessment Model to Contingency Planning
Objective: Adapt and test the manpower model for supply contingency manpower planning purposes.
Capt Burleson, AFLMC/LGS, AUTOVON 446-4165

Computer Assisted Transportation System—Fleet Analysis Module
Objective: Develop an automated fleet analysis system to assist base-level vehicle operations units. The system must be able to transfer data from the on-line Vehicle Integrated Management System (VIMS), where appropriate, and provide a means to enter data manually, put it in the correct format, and provide a set of standard reports and graphs. In addition, it must allow easy ad hoc inquiries of any set or subset of data and operate through understandable menus.
Capt Van Scotter, AFLMC/LGT, AUTOVON 446-4464

Parts Automated Reparable Tracking System (PARTS)
Objective: Provide maintenance and supply managers with accurate, up-to-date status and location of reparables in the repair cycle process.
Capt Hayes, AFLMC/LGM, AUTOVON 446-4581

War Readiness Spares Kit (WRSK) Requirements Computation
Objective: Compare the current method of computing WRSK requirements with alternative methods and recommend the best method for Air Force use.
Maj Blazer, AFLMC/LGS, AUTOVON 446-4165

Maintenance Airframe Capability Assessment
Objective: Provide a more precise unit level capability assessment methodology for predicting the capability of possessed airframes to support flying requirements.
MSgt Teasley, AFLMC/LGM, AUTOVON 446-4581

Contingency Base Support Requirement Forecasting
Objective: Evaluate the Combat Follow-On Supply System (CFOSS) to determine if established policy will support weapon system requirements following the initial WRSK/BLSS 30-day support period. Examine wartime supply requirements for other than weapon system items and develop policies and procedures to support base functions whether they fight in place or at a deployed site.
Capt Burleson, AFLMC/LGS, AUTOVON 446-4165

Reparable (XD) Item Retention Policy
Objective: Analyze XD items. Develop alternative retention policies and determine the efficiency and effectiveness of alternative retention policies.
Capt Ham, AFLMC/LGS, AUTOVON 446-4165

Freight Documentation Automation
Objective: Reduce manual workload by automating data entry, storage, and output in the base-level surface freight transportation functions. The first will be documents such as intransit data cards (IDCs), transportation control movement documents (TCMDs), government bills of lading (GBLs), shipping labels, and various T-WRAPS data.
Maj Walker, AFLMC/LGT, AUTOVON 446-4464

TO 28 ▶

The US Industrial Base: Can It Provide Enough Precision Guided Munitions?

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Numerous articles in the popular press over the past five years have characterized the defense industrial base as weak, unproductive, and even obsolescent. Less well publicized are high level Department of Defense (DOD) efforts to evaluate the validity of such characterizations and to develop strategies to overcome existing deficiencies. This article reports one such effort: A Joint Chiefs of Staff (JCS)-initiated study to determine industrial preparedness measures (IPMs) that could be taken to ensure the availability of precision guided munitions (PGMs).

Background

Over the past 20 years, our military effectiveness has been determined increasingly by our ability to destroy targets with PGMs. Traditional DOD policy has been to purchase sufficient PGMs to cover planning objectives. Fiscal constraints and competing priorities now preclude this approach. Should a crisis occur, DOD would be forced to rely on industrial production increases to make up the current PGM shortfall.

The capability of industry to rapidly increase, or surge, production of defense items has been an area of growing interest for several years. The *1984 DOD Industrial Responsiveness Simulation* and other DOD-initiated production studies looked at the issue in general. An Air Force Tactical Missile Panel looked specifically at PGM production surge in an FY84 Production Base Analysis (PBA) entitled *Blueprint for Tomorrow*. These studies showed that, basically, industry could not achieve and sustain a 50% production rate increase within six months of startup because of deficiencies in input materials, special tooling (ST), and special test equipment (STE).

In June 1984, the "Blueprint" Tactical Missile Panel held a follow-up meeting with Organization of the Joint Chiefs of Staff (OJCS) participation. Because of PGM production problems common to all services and Commander-in-Chief (CINC) identification of PGMs as critical, war-fighting assets, the Panel participants recognized a need for a *joint* Service study—one that also would have direct input from industry leaders. Individual Service analyses of the PGM production base would not accurately describe the total DOD production problems affecting readiness and sustainability.

A joint working group was formed from the Services, the OJCS, and the Office of the Secretary of Defense (OSD) with direct continued support by the Tactical Missile Panel industry vice-presidents. Later, the working group expanded to include participation by the Department of Commerce, the Federal Emergency Management Agency, the Central Intelligence Agency, and the Canadian National Defense Headquarters and Department of Supply and Services. This study differed from its predecessors by its *joint* coverage of all four Services' requirements and its use of *specific* surge and mobilization targets based on a common Defense Guidance scenario. It was also the first one to look at an *entire* sector of industry, assessing the sector both horizontally among all the prime contractors and vertically down through the critical subcontractors. Such subcontractors comprise more than 80% of the cost of a PGM.

PGM Analysis

Phase I: Prime Contractors

Phase I of the study ran from September 1984 through February 1985. It was structured to address the capability of PGM *prime* contractors to achieve peacetime surge and wartime mobilization targets; identify the subcontractor base in support of the prime contractors; identify internal and external production constraints prohibiting attainment of surge and mobilization targets; and recommend and give the cost of IPMs needed to resolve these constraints and production bottlenecks during peacetime. Specific targets of the study were 20 PGMs (Table 1) identified on CINC Critical Items Lists.

PGM		PRIME CONTRACTOR
CHAPARRAL	MIM-72E	Ford Aerospace
COPPERHEAD	M712	Martin Marietta
*PAVEWAY III	GBU-22,23,24	Texas Instruments
*GBU-15	GBU-15(AGM-130)	Rockwell
**HARM	AGM-88	Texas Instruments
**HARPOON	AGM-84, RGM-84 UGM-84	McDonnell Douglas
HELLFIRE	AGM-114A	Rockwell Martin Marietta
*IR MAVERICK	AGM-65D	Hughes
*LASER MAVERICK	AGM-65E	Hughes
MK 46 TORPEDO	MK-46	Honeywell
PATRIOT	MIM-104	Raytheon, Martin Marietta
PHOENIX	AIM-54	Hughes
RAM		General Dynamics
**SIDEWINDER	AIM-9	Raytheon, Ford Aerospace
SM 1 BLOCK VI	RIM-66	General Dynamics
SM 2 BLOCK II	RIM-67	General Dynamics
**SPARROW	AIM/RIM-7	Raytheon, General Dynamics
**STINGER	FIM/92A	General Dynamics
**TOMAHAWK	BGM-109	General Dynamics, McDonnell Douglas
TOW	BGM-71D	Hughes

* = AF-Procured
** = AF-Used

Table 1: PGM Usage and Procurement.

Phase II: Subcontractors

Phase II was begun in May and completed in October 1985. It analyzed *subcontractors* from seven specific PGM industry sectors—propulsion, electronics, mechanical components, metal parts, microwave technologies, ordnance production, and a miscellaneous category—as to their abilities to satisfy the requirements of prime contractors.

The Scenario

The Joint Working Group and industry developed as the basis for the analysis a comprehensive questionnaire (synopsized in Table 2) designed to meet all the Services' planning needs. It also enabled the collection and assessment of uniform, consistent industry data.

Current Capacity/Capability Profile - A summary of current production resources, including special tooling and test equipment, capital equipment, floor space, and labor.

Surge Form - The surge potential for each PGM, assuming required IPMs would be funded. Identified were the month-to-month production rates necessary to achieve and sustain the surge targets at or before month six.

Rolling Inventory Form - A price list of the complete bill of materials.

Constraint Identification Form - Production constraints to acquiring components and materials as well as to manufacturing and testing PGMs.

Industrial Preparedness Measures Form - Characterized in terms of their place in the manufacturing/testing cycle, their costs, and their contributions to the contractor's ability to eliminate surge and mobilization constraints.

Mobilization Form - Analogous to the surge form, a month-by-month analysis of the production rates necessary to meet mobilization targets by S/M-day plus 24 months or sooner.

First-Tier Subcontractor Listing Form - Components purchased from first-tier vendors listed in decreasing dollar order until 80% of the value of the PGM materials was accounted for. The 80% figure was chosen because prime contractors suggested that virtually all items whose production might be constrained under surge conditions would be included by this criterion. Identification of other known critical subcontractors from the remaining (20%) list was provided.

Table 2: Specific Components of Questionnaire.

The study used 1 October 1986 as the assumed surge and mobilization start date. Surge targets *averaged* about 1.5 times the planned October 1986 production rate. There was, however, considerable variation in the Services' planned target rates, with some PGMs expected to triple production from the planned peacetime production rate while others had only modest increases. Production targets for mobilization day plus 24 months averaged about four times the October 1986 production rate.

Surge Versus Mobilization

The study focused on surge in a peacetime crisis because it was perceived that surge is the appropriate response to a wider range of crisis situations than mobilization (Table 3). This would include surging production of systems needed to resupply an ally instead of drawing down US war reserve materiel, surging in pre-crisis with a warning to decrease readiness spares shortfalls, and surging PGMs needed for a particular crisis scenario. Since surge is a logical precursor to mobilization, surge problems must be solved before mobilization problems can be solved.

SURGE: A rapid increase in production within existing "brick and mortar" during peacetime which will result in a significant increase in sustained production rates.

MOBILIZATION: A structured, systematic build-up from the surge production rate to significantly increase incremental production target rates in months 12, 18, and 24.

ROLLING INVENTORY: Prestocking raw materials, semifinished materials, components, and subassemblies necessary to produce the end item, using them on a first-in, first-out basis, as well as performing the work required on these items to prepare them for immediate release to the plant floor in the event of surge or mobilization.

Table 3: Key Terms.

Assumptions

The following assumptions were given to industry:

(1) The US would be in a peacetime, business-as-usual posture.

(2) All funding would be immediately available when surge begins (no administrative lead time and in-place contracting procedures, forms, etc.).

(3) Producers would be requested to accelerate production with no addition to the unit cost of producing PGMs.

(4) The Defense Priorities and Allocations System would be rigorously enforced. This assumes the DOD Master Urgency List and the CINC Critical Items List (CIL) would be integrated and reprioritized as needed by the Joint Material Priorities and Allocations Board.

(5) No variances would be allowed in quality and reliability standards.

"The ability to surge production of all 20 PGMs to meet joint service targets is an achievable goal if...."

Findings

The ability to *surge* production of all 20 PGMs to meet joint Service targets is an achievable goal *if* that capability is funded now for a lead time of some 12 to 22 months (Figure 1). The cost is low ($1.8 billion), relative to an annual cost of PGM procurement ($4.0 billion), and most of the rolling investment is recoverable as part of the last production buy. Also, ST/STE reverts to government use in post-production support. The

mobilization targets could also be met; however, the cost would be approximately four times that for surge. Interpretation of these cost figures, and the ones that follow, should be tempered by the fact that the study did not consider the cost of government-furnished material or equipment (GFM/GFE).

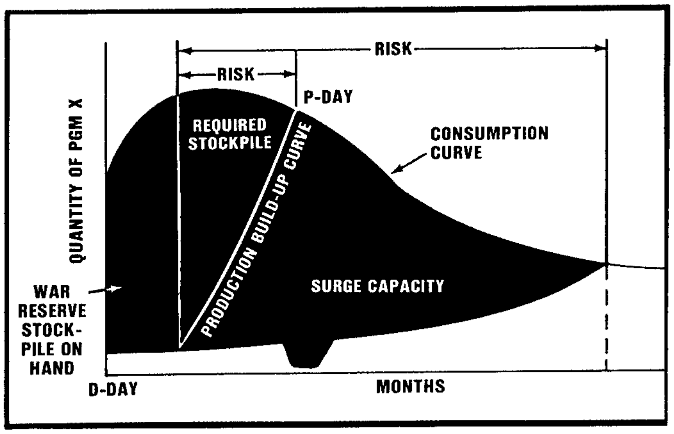

Figure 1: Investment in industrial surge capability dramatically decreases the risk of PGM production.

Surge Summary

- All PGMs require a rolling inventory of long lead time pacing items (Table 4), but the final cost is low compared to buying one year's worth of all-up PGM rounds. Contractors do not fund for surge capability. This investment cost ranges from several millions up to almost $300 million per PGM. Five of the twenty PGMs studied can achieve surge capability for less than $30 million each, while an additional ten can be provided with surge capability for between $30 million and $80 million each.
- Most PGMs require investment in STE, ST, and general plant equipment (GPE), the total cost of which is $0.5 billion. Prime contractors especially need STE, which is often used much more than the normal PGM single production shift of eight hours per day, five days a week.
- Competitive procurement of rolling inventory and ST/STE would eliminate contractors from having surge capability and is therefore *not* recommended. Note that having dual production sources does not negate the need for surge funding, since rolling inventory and needed STE still may not be available.
- Investment in surge is tied to the five year defense plan (FYDP) process. Achieving a PGM surge capacity requires the Services to fund surge in their Program Objective Memoranda (POM), "fencing off" industrial programs such as surge as a needed capacity hedge for weapon stocks shortfalls.
- Expansion, rather than new "brick and mortar" construction, is normally possible through the displacement of administrative functions and lower priority programs. For those PGMs receiving surge funding, contractors must develop detailed surge plans.
- Preplanning for surge contracting is necessary. All PGM contracts should incorporate surge requirements and clauses to ensure a smooth, rapid contractual transition to surge.
- There is some dependence of multiple PGMs on a common base of subcontractors, some of which are sole and single sources. The government should fund the qualification of additional sources and ensure their continued availability.

CONSTRAINT	RECOMMENDATION	NUMBER PGMs INVOLVED
Inventory inadequate for surge production levels	Fund rolling inventory	20
ST/STE shortage, recognizing lead time to build and install equipment	Acquire ST/STE adequate to meet surge requirements prior to surge-day	15
Vendor lead time	Multiple or second sourcing; "DX" national production priority; fund rolling inventory; fund facilitization and manufacturing improvements at subcontractor facilities	9
Lack of facility space	Lease work space and have prefab buildings available	5
Shortage of personnel for additional shifts	Establish differential salaries	5
Government QRA, lot testing requirements	Change lot size to reflect surge production rates; allow more contractor responsibility for QRA	4
Shortage of production equipment and tooling	Buy and proof additional equipment and tooling	4
Too many vendors are single or sole sources	Develop and qualify alternative vendors	3
Requirements to use small business and disadvantaged business vendors	Change requirements to objectives for surge item contracts	3
Late arrival of GFE/GFM	Prestock at vendor level; develop second sources; convert to contractor-furnished equipment (CFE)	3
Vendor capacity inadequate to supply prime contractor needs for surge	Improve vendor methods and technology; develop additional vendors to increase base of tooling and facilities at sub-tier level	2
Ground transportation for materials and personnel	Initiate a government study of transportation capability in emergency situations	2
Minor design changes require too much time for government approval	Establish "local" change control, such as contractor control for Class 2 changes	2
Dependence on foreign sources	Develop capability to produce these items in the US or add to national stockpile	2
Constraints of annual funding adversely affect availability of components	Allow multiyear funding	2
Shortage of skilled personnel	Use personnel from other programs in an emergency; establish a control center for personnel information, similar to that developed for use in a strike	2
Lack of capital equipment	Fund capital equipment acquisition	2
Lack of explosives handling space	Add bunker space	1
Lack of storage space for inventory	Lease additional space	1
Shortage of critical/strategic materials	Use an allocation system; establish local stockpiles at contractor facility	1

Table 4: Constraints to Achieving Surge.

- The prime contractors are basically all government-oriented operations. However, the subcontractors have some potential to switch from commercial to PGM production in order to free up extra capacity.
- Labor availability is *not* viewed as a critical constraint. Differential pay incentives, recall of recent retirees, and in-plant training programs will provide both technical and manufacturing personnel for multiple shift operations.
- The number and location of Ready Reservists within the PGM industry for critical manufacturing line manning are unknown. Problems may result if these individuals are mobilized. Planning must identify and resolve potential conflicts, especially at the subcontractor level, prior to a mobilization.

- The subcontractor base must be directed to surge production *before* the prime contractors. Otherwise, pipeline depletions could occur. This might entail an early US response to enemy industrial base production increases.
- DOD must fund IPMs so each PGM program can be surged individually or in conjunction with other PGMs.
- The small numbers of currently available spare PGM parts, if assembled, could not produce any meaningful number of new PGMs. No PGM has a readily available stock of each component part needed.
- There is *no* risk of technological obsolescence since rolling inventory is used on a first-in, first-out basis.

Mobilization Summary

The conclusions for mobilization are much less definitive. Achieving mobilization targets will require a significantly higher level of investment, and the means for surmounting other constraints requires additional analysis.

- The cost of establishing an inventory and ST/STE/GPE would be over $6.0 billion beyond the cost for surge. Again this figure does not include costs of government-furnished material or equipment. Additional "brick and mortar" will be required along with the displacement of all but critical manufacturing functions.
- Serious labor constraints would occur in mobilization that can only be resolved through labor shifts in favor of defense products, or by expanding the base from non-defense oriented industries.
- Foreign source dependency, and especially vulnerability, are potentially severe constraints to mobilization. The degree of dependency and vulnerability requires further study to define specific areas where levels of domestic self-sufficiency are needed.
- Transportation, both of employees and materials, is likely to be a constraint because of limited availability of fuel and higher demands for transportation services.

Conclusion

The Services, OSD, and OJCS cannot pause at this juncture. There must be continued planning to reduce or eliminate current or possible constraints and production bottlenecks caused by such factors as:

- single or sole sources and competing Service and contractor resource demands,
- dependency on, and vulnerability of, foreign sources of supply,
- lack of multiyear contracts which would allow for some type of long lead-time inventory,
- skilled manpower and materiel shortages,
- lack of surge contracting procedures and surge plans,
- lack of an automated manufacturing data base within DOD to instantaneously assess production bottlenecks and industrial capability,
- concentration of PGM component producers west of the San Andreas fault, an area of known earthquake vulnerability,
- any action which threatens to close down a sole or single source producer for several PGM lines,
- lack of rolling inventory for pacing components along with ST/STE/GPE,
- lack of enough modern machines, machine tools, and adequate modernization incentives by industry or the government, and
- peacetime business-as-usual procurement with insufficient relationships to identified war-fighting needs.

This article has reduced to a few pages the many findings of a complex report. But while the findings may be complex, the overall theme is simply stated. Budget constraints do not permit buying and stockpiling needed PGM weapons; a less costly alternative approach is investment in industrial surge capacity.

Without such upfront surge investments by the Services, industry will continue to be sharply limited in its ability to rapidly increase production rates. In the precision guided munitions field, absence of upfront investment means one or two years could elapse before substantial production increases could be realized. Considering the importance of PGMs to the nation's war-fighting needs, that degree of risk is unacceptable—and avoidable. JL

DMSMS Program

The Air Force is establishing new policies to deal with the increasing problem of diminishing manufacturing sources and material shortages of spare parts. Air Force Regulation 78-7, *Diminishing Manufacturing Sources and Material Shortages (DMSMS) Program,* is being published to implement the program and establish responsibilities for DMSMS actions. The objective is to minimize the impact of a shrinking industrial base and shortages of raw/semifinished material on defense weapon system programs by initiating prompt actions to ensure the continued availability of manufacturing capabilities, essential materials, end items, and parts needed to support current and planned defense requirements. The new regulation should be in the AFR 0-2 by March 1986.

"I believe that investment in surge production capabilities strikes a prudent balance between the surety of fully adequate war reserves on hand, and the risks of postponing significant sustainability improvements until the out years. Moreover, tightening budget constraints may argue for greater investment in these surge capabilities. I suggest, therefore, that in the current POM process we consider funding the investments necessary to develop surge production capabilities for your top priority PGMs and other critical consumables."

William H. Taft, IV
Deputy Secretary of Defense

PRO/CON QUEST *Studies for the Logistician...*

The Myth of Free Trade

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Over 200 years ago, Adam Smith propounded the idea of free trade. His proof was by analogy. If a person made all his own goods, he could not do nearly as well as making only one good and trading for others. As an example, he could make his shoes and clothing, and do neither very efficiently, or he could make shoes only and trade them for clothing. The tailor and the shoemaker would both become wealthier due to the efficiencies of specialization. Smith then generalized this logic to apply to nations.

David Ricardo carried the argument one step further, stating it is *relative* advantage that counts, not *absolute* advantage. If Japan were better at both steel and autos than the US, but relatively better at autos than steel, then Japan should make most autos and the US most steel. We could still trade and both become wealthier.

Smith and Ricardo used relatively simple mathematics to make the point that free trade benefits the trading nations. Economics books are full of additional mathematics purporting to prove the same point. It took over 200 years for the argument to become deeply embedded in the economic and national psyches. Since 1933, and particularly since 1945, these ideas have driven American trade policies. But in *International Trade and the Future of the West,* John M. Culbertson, Professor of Economics at the University of Wisconsin, finds the underlying assumptions of the free trade model do not fit reality; therefore, the conclusions of the free trade model are faulty. Nations do not automatically become wealthier through unimpeded trade.

If Adam Smith, David Ricardo, and their modern day clones at the universities are wrong, many major American industries are in severe trouble. These include steel, autos, textiles, clothing, shoes, machine tools, electronics, ship building, and the merchant marine, all of which are under heavy attack from imports.

When means of transportation were slow and expensive, the potential damage of unrestricted trade was not excessively serious. The high cost of slow transportation acted in lieu of tariffs to restrict trade. With fast, inexpensive transportation, low cost manufacturing nations are in a position to destroy industry in the high cost ones. Followers of Smith and Ricardo simply explain that this is the way the market works. Unfortunately, this answer no longer suffices. When the textile and clothing industry shifted from the highly unionized North to the South, Americans in New England lost jobs, but Americans in the South gained them. Although wages in the North were depressed, those in the South went up. As Americans, we could look at the situation with equanimity, so long as we were not among those Northerners who lost their jobs. When the situation is shifted, and Americans lose their jobs to Taiwanese, Japanese, Mexicans, and Brazilians, the situation is somewhat different. We cannot be as sanguine about this as about the internal American trade shift. The need for jobs increases in Third World countries because of exploding populations. Therefore, they will always have excess labor supplies ready to undercut ours.

In his book, Culbertson shows that the cost of labor is directly related to its supply. This will continue until American wages are depressed to the levels of Mexico and Brazil—not an inviting prospect. Culbertson also discusses immigration as a factor in international trade. If the population is allowed to grow, whether internally or through immigration, the added supply of labor must depress wages. Since Third World nations have no really effective means of stabilizing their populations as of now, they have the potential to destroy the American standard of living. Illegal immigration is especially dangerous since at present it is high and, many think, out of control.

Another danger from the Third World countries is that their large populations, because of dire poverty, will be willing to work at lower *social* costs. Pollution control, safety, conservation of natural resources, child labor restrictions, unemployment compensation, and pensions are minimal because of the extreme need for employment. A low social overhead enables these countries to engage in destructive competition. A sort of Gresham's law of industry results as bad social and industrial practices drive out good.

Professor Culbertson offers a remedy to these problems—he thinks international trade must be conducted on a government-to-government basis, in order to ensure national interests are considered. But, although his points about the catastrophe we are now witnessing in American international trade are important, anyone involved with governmental decision making will be less than comfortable about letting government officials make international trade decisions.

> *"As military logisticians, we must take more than a passing interest in unregulated international trade."*

My solution to assure balance of trade is to establish adjustable tariffs. In another article, I proposed a 25% tariff on all imported manufactured products. Unfortunately, this would probably damage nations with whom we are in trade surplus as well as those with whom we are in deficit. Perhaps a better suggestion is that those nations with whom the US has had substantial deficits for three years in a row would have a 25% tariff applied. The tariff would be adjusted up or down for individual nations, depending on whether the balance was positive or negative. For example, if the balance were more than 5% in deficit in a given year, the duty would be raised 5%

for the following year. If a 5% or more trade surplus occurred, the duty would be lowered by 2% for the following year. This would be a form of self-regulation. As long as a nation bought from us, they could sell to us. Dumping, as currently practiced by Japan, Taiwan, Singapore, Brazil, Canada, Mexico, Italy, and others would no longer be possible. Trade would be brought into balance without the direct intervention of bureaucrats. The mechanism would be self-regulating.

Our industry is a valuable asset. To permit it to be sacrificed to the free trade myth is suicidal. We need industry and jobs, and we need them in both war and peace. As military logisticians, we must take more than a passing interest in *unregulated* international trade. (I do not use the term "free trade" since we are conditioned to consider anything "free" as good. So-called "free trade" is really anarchic trade, equivalent to playing football with two sets of rules. Only an unmitigated disaster can follow for one side.)

In the civilian world, this loss of industry and jobs means a depressed economy and standard of living. In the military world, it means the heart of our industrial system is being destroyed. When 20% to 25%—and on occasion 50% (shoes)—of our critical manufactured goods are imported and the manufacturing plants dismantled, the basic security of the US is placed at high risk.

As Americans we must be concerned with the loss of jobs and industry. As military logisticians, we must be concerned with loss of *the* basic logistic resource, our industry.

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Statistical Analysis: Do Logisticians Need It?

P. J. French

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The reasonableness of many logistics methods has recently been questioned. Because of the high costs of logistics support, only those methods statistically valid can be justified; logisticians are becoming increasingly aware that they must show a scientific foundation for the support they provide. In addition, larger numbers of logisticians are earning baccalaureate and postgraduate degrees. As a result, practicing logisticians are conducting more research throughout the Air Force.

Statistical Analysis is a chief tool of the research logistician. Quantitative research should not be designed or conducted, nor the resulting data analyzed, without the use of statistical methods which enable the researcher to translate numbers into meanings. The real value of research project results can be gleaned only *after* the statistical *significance* of the data has been determined. Data interpretation without the use of statistical analysis affords a statement of opinion rather than scientific fact. (Opinion is unsubstantiated information lying somewhere between ignorance and truth.) Research without statistical analysis of the results is faulty science. Moreover, statistical principles are integral to the entire research process, not just to data analysis. A knowledge of statistical principles enables the logistics researcher to determine the appropriate sample size, to obtain random samples, and to select the most appropriate study design to address research questions. Even so, statistical analysis permits inferences to be made with relative but not complete certainty. Statistical inferences are based on probability, so it is possible, although unlikely, that correctly drawn inferences can be incorrect information.

The three types of statistical analysis of primary interest to the logistics researcher are *descriptive statistics, inferential statistics,* and *correlation and regression*.

a. *Descriptive* statistics is employed to discover the central tendency (mean and median) and the variability (standard deviation and range) of data.

b. *Inferential* statistics is used to find out a P value—the probability that the difference between two or more samples occurred by chance. For example, $P<0.05$ means that the probability is less than 5% that the difference between samples is due to chance alone. Looking at it another way, this means there is a greater than 95% probability that the difference between data points was a "real" difference, not just the outcome of chance. Some common tests used in inferential statistics are the student's T test, analysis of variance, and the chi-square test.

c. *Correlation* is exercised to establish the correlation coefficient (r), which expresses the "strength" of the relationship (not necessarily cause and effect) between two or more variables. A scatter diagram is typically used to illustrate this relationship graphically. *Regression* analysis, used to express the "form" of the relationship between variables, determines the line that best fits the data points represented by the relationship.

Although the computer can help with the math related to many statistical tests, and although statistics software packages are available for both mainframe and desktop computers, researchers must have a basic knowledge of statistics—or enlist the help of someone with such knowledge—if they are to avoid errors. The right statistical tests must first be selected. Further, the tests should be identified during a study's *design* phase, before data are collected. Nonetheless, a typical error made by researchers is the practice of setting up a database, then having the computer calculate all the variety of statistical tests for which it is programmed, and finally choosing the test that apparently indicates the data are statistically significant. At best, this procedure shows a lack of understanding of statistical principles; at worst, the practice is an intentional abuse of statistical science in an attempt to get the desired outcomes.

How can the working logistics professional learn more about statistics without becoming hopelessly mired in complicated formulas and cryptic explanations? There are a few books available that take a "user's view" in presenting statistical methods. One humorous book is *Flaws and Fallacies in Statistical Thinking*.[1] The author describes its contents quite well at the start of the first chapter:

> This book is unusual. Textbooks show you facts and right methods. This book shows you fallacies and wrong methods. It will serve as a

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READER EXCHANGE

Dear Editor

I agree strongly with General Curtis's letter (*AFJL*, Fall 1985) that we may be placing too much emphasis on Reliability and Maintainability at the expense of survivability, operability, and integrated logistics support in wartime or contingencies. While assigned to PACAF, USAFE, and HQ USAF, I came to the conclusion that there are two major deficiencies in the logistics planning system. First, we place little or no emphasis on contingency requirements during the acquisition process. Initial Optimum Repair Level Analysis (ORLA) for spares is based solely on peacetime home station requirements, while equipment acquisition decisions rarely are based on mobility, survivability, or spares versus equipment cost-benefit analyses. PACAF's *Repair the Spare* program, initiated by Major General Thomas A. LaPlante, PACAF/LG, is designed to rectify the ORLA problem but at a stage in the acquisition process in which the economic impact of previous ORLA decisions may make changes, no matter how smart, cost prohibitive. The second major problem is lack of a common set of wartime assumptions within the various logistics communities. For example, there is no relationship between the failure rates used to determine WRSK/BLSS spares requirements and those used to compute maintenance manpower requirements. Similarly, there is no common basis for determining the equipment authorized to support an aviation unit type code (UTC), the WRSK for that UTC, or the UTC maintenance manpower requirement, as none of these packages are built based upon similar assumptions. To further complicate the situation, assumptions used for engines also vary widely from those used for the other commodities.

The problem, simply stated, is that HQ USAF is primarily involved with programming and budgeting while the commands concentrate on the peacetime flying hour program. As a result, planning for contingency requirements suffers. It appears that, all too often, exercises in which disproportional amounts of logistics and command and control assets are used to support relatively small forces (e.g., Grenada and tactical deployment) are yardsticks of the success of current logistics planning and of how we do business. This ignores the compelling logic of General Billy Minter who, as the USAFE/LG, said that "TAC deployments only prove that given the combined resources of USAFE and TAC, we are able to barely support one squadron flying well below its wartime sortie rate given intensive preplanning and deployment preparation." In other words, while exercises are indicative of many things, wartime logistics supportability is not one of them. Unfortunately, we continue to draw the wrong lessons from these built-in success stories.

> *"The assumption that the LOC can be a giant MICAP control center is not valid . . . ."*

A prime example is Grenada. Because the AFLC Logistic Operations Center (LOC) was able to divert resources around to support the relatively small force engaged, some drew the conclusion that this would also be feasible and desirable in a general war scenario. The assumption that the LOC can be a giant MICAP control center is not valid because it currently lacks the resources or tools to look at distribution in a global war environment. That is not doable with the tools or models available today or in the near future. Even using a vastly simpler one-theater scenario, the whole thrust of the LOC planning system is to push everything to the theater based upon probabilities obtained from a requirements model of doubtful validity. A short-term effort might be having AFLC dovetail end item resupply with DLA/GSA bit and piece support to ensure a continuous flow of resupply. This is much harder analytically but a better representation of wartime requirements.

> *"We need to stop confusing our ability to support peacetime flying with how well we could sustain wartime flying to ensure we have the right logistics resources if a contingency occurs."*

In summary, we need to refocus on our logistics planning efforts to ensure that supply, maintenance, munitions, and manpower are prepared to fight the same war. As a start, a study group, such as CORONA REQUIRE, might look at the assumptions used to compute spares, equipment, engines, and manpower to ensure they are compatible. Once this is done, the group could then see what improvements should be made to contingency logistics support planning in the acquisition process. We need to stop confusing our ability to support peacetime flying with how well we could sustain wartime flying to ensure we have the right logistics resources if a contingency occurs.

Lt Colonel Joseph B. Corcoran, Jr., USAF
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Osan AB, Korea

Dear Editor

It was good to see the emphasis Air Force Communications Command (AFCC) is placing on reliability ("R&M: A Short Tutorial," Winter 1986). I agree that availability measures can be misleading. Availability is only meaningful as an asymptomatic, steady-state, stationary process. It does not relate to the avionics community, the space community, nor the missile community. In the missile community, availability is highly dependent on nonoperational dormant storage, rather than on operating time, which may only be in seconds. The only people still using availability are the Mitre and Aerospace Corporations, who prepare technical specifications for major acquisitions.

But I am concerned that the tutorial oversimplifies the application of reliability measures. The material presupposes that the reader knows what availability is and understands it in AFCC terms of mean downtime and mean time between critical (or downing) events. The textbooks discuss availability in terms of MTBF and mean time to repair. There are different kinds of availability—inherent, intrinsic, achieved, and operational—depending on what is included in the maintenance time segment, such as other-than-correctional maintenance. The largest effect is that of *logistics delay*, but we cannot let the contractor's design for maintainability be influenced by Air Force logistics delays that are orders of magnitude more than the time to repair. Also, special stocks of war reserve materiel (WRSK spares) are often carried with equipment to provide immediate replacements so that, for the surge period, MDT becomes half-an-hour or less, not the peacetime 12- to 31-day supply lag. In a wartime situation, with adequate WRSK and no battle damage, actual availabilities approach intrinsic values. In peacetime, the operational availability is approached.

> *"It is not the critical failures that are important logistically; it is the maintenance actions."*

In my opinion, the tutorial misses the point in stressing MTBCF. It is not the critical failures that are important logistically; it is the *maintenance actions.* MTBCF is an operational viewpoint and MTBM is a logistics viewpoint. Human factors engineers would be concerned about what happens when people react to a critical failure and what can be done to the design to make recovery as rapid as possible. They would also be concerned when a technician has to perform a maintenance action (failure or no failure). The human factors approach is inclined towards the *maintainability* side of the house, not the *reliability* side. The problems of the supply system and delays are not specifically germane to the AFCC situation. For continuous ground C-E equipment, maintenance can go on while the system operates. Some large systems such as the Precision Location Strike System (PLSS) and the North American Defense System have elaborate redundancy that allows for continuous maintenance with very small probabilities of a critical failure occurring.

Readers should also be cautioned against assuming that a *specified* MTBF leads to the same *delivered* MTBF. A large problem in MTBF specification is that it involves such factors as contractor chargeables, equipment being developed in very fluid design situations, congressional constraints and regulations requiring use of specific equipment and components, dead guesses on the reliabilities of components, no good idea of what equipment reliability could be if new technology and high reliability design approaches were used, extremely brief testing, and program management pressure to deliver hardware on schedule, within budget and having at least some operational capability. As a result, programs usually end up with equipment having really *unknown* MTBFs. (The actuality varies within the Air Force. In the avionics community they speak of MTBF goals that they hope to achieve 3 to 5 years after the equipment is installed. In the space community it is by extremely close attention to reliable design and long satellite life (*no* MTBFs) that they get immediate high reliability.) Further, it is worthless to specify an MTBCF design goal of 14,400 hours if there is only 3,000 hours of reliability testing in the program. If one specifies a 14,400-hour MTBF goal and accepts MIL-STD-781 test plan VIIIC or 30-1, then the lower test MTBF is 1,744 hours for the former and 2,500 for the latter. That

is, for 3 times out of 10, the actual equipment MTBF is less than these values. This is one reason why we still get the 50 hour MTBFs. There is no substitute for reliability *testing*.

"The conclusion that 'availability is not the best way to specify system performance' is certainly true."

The conclusion that "availability is not the best way to specify system performance" is certainly true. There are too many assumptions in any test method to test for availability; it takes an enormous amount of test time and therefore cannot be directly demonstrated. A failure rate or MTBF can be demonstrated based on only one assumption—the exponential distribution characteristic. Maintainability can be tested by the use of simulated faults and, within a short time period, demonstrate fairly well if the equipment is maintainable or not. Either parametric or non-parametric tests for the mean and percentiles can be made. From both of these values, independently arrived at, estimates of availability can be made. I personally do not use availability in specifications and try to get existing availability requirements deleted.

David A. Heiser
Reliability Engineer
Sacramento ALC

Dear Editor

Colonel George Kishiyama, in his excellent article "The Relevance of Doctrine to Air Force Civil Engineering" (*AFJL*, Winter 1986), identifies the need to develop coherent support doctrine for a specific mission or functional area. The process of logistically supporting space operations likewise demands doctrinal scrutiny. The Air Force has conducted operations in space for more than 25 years without the benefit of written doctrine on how those operations should be logistically supported. For much of that time, however, space systems were considered to be in a lifelong "flight test" or research and development (R&D) status. Today, with the establishment of the Air Force Space Command (AFSPACECOM) as an operational command, and given AF Chief of Staff direction to normalize space operations (including logistics support), the Air Force is obliged to examine its assumptions, contending theories, policies, and beliefs on how best to support space operations—in other words, to develop doctrine.

"Doctrine establishes that going-in position."

Without a coherent space logistics doctrine, the Air Force has neither a common understanding of terms and assumptions nor a common acceptance of the best way to support space systems. The result is no clear, unconstrained vision of what space logistics support should be. In the absence of such a vision, "things" become more important than *ideas* about what to do with them. We are forced to rely on high technology, hardware solutions to what are essentially conceptual questions. Examples of this abound; if we examine any space system, we will find design solutions driving support requirements instead of the other way around. This situation is not unique to space systems of course, and logistics considerations cannot always overshadow other operational requirements. The point is, in space systems we cannot effectively make these kinds of trade-offs, because there is no "going-in position" on what the support arrangements should be.

Doctrine establishes that going-in position. Inasmuch as doctrine prescribes a norm or standard of conduct, it becomes one of many factors—political, legal, technical, economic—that push and tug at each other in a battle to ultimately influence policy. Even though doctrinal requirements are frequently overriden (even overwhelmed) by other factors, we owe both ourselves and other policymakers a best shot at articulating our beliefs.

Good, coherent space logistics doctrine will not only provide a baseline that prescribes how to use the "things" we have, it will also establish goals and standards of performance for our people. The space logistics community is a large, diverse group that includes blue suiters, civilians, "three-levels," and senior decision makers; doctrine establishes a common sense of purpose and produces the team spirit and commitment to mission required to get the job done.

"Abstract thinking is difficult, and the number of people that practice that skill is fewer than we would like to admit."

Developing good space logistics doctrine is not easy—if it were, we would have already done it. In the first place, the reward is far more real than apparent. After all, the argument goes, "we're getting along fine without it." In addition, the process of developing it is harder than it seems. Abstract thinking is difficult, and the number of people that practice that skill is fewer than we would like to admit. Most of us spend our careers developing the coping skills—the ability to think on our feet, to run in the mud—that the responsibilities of our job demand. Few of us step back and address the abstract, doctrinal issue of *why* we are standing in the mud in the first place.

Then there is the temptation to write doctrine to support current policies (thus legitimizing an organizational or resource *status quo*) or to advocate future programming strategies. Both of these are appropriate functions of doctrine, as long as the doctrine precedes the policies and programs, rather than the other way around.

"Few of us step back and address the abstract, doctrinal issue of why we are standing in the mud in the first place."

Finally, the pathway to good doctrine is obscured by the notion that space logistics is "unique," and past experience with "wings and wheels" is irrelevant. To paraphrase Samuel Coleridge, if we blind ourselves to lessons already learned, then the light of experience is but a lantern on the stern, shining only on the waves behind. Surely the principles of combat and combat support, representing all we know about operations on the land, on the sea, and in the air, apply to operations in space as well.

Major James C. Miller, IV, USAF
Air Force Logistics Command
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▶ *FROM 35*

companion to any textbook on statistics. It will also serve as a self-help guide to distinguish between valid and faulty statistical reasoning.

As an example of a fallacy concerning adding and subtracting percents, the author tells about a man who put two setting hens on his automobile motor on cold nights. "A setting hen's temperature is 102," the man explained, "and consequently two hens is 204. With this heat the engine is sure to start the first time it kicks over."

A second book, *Studying a Study and Testing a Test,*[2] communicates more than statistics (e.g., it says a lot about study design—and should be invaluable to logistics researchers), but its treatment of statistics is more helpful. A nice feature is a flow sheet at the end of the book which enables one to determine graphically the correct statistical test to employ for a given data set. The process can also be reversed: A researcher can start at the bottom of the flow sheet, where the various statistical tests are listed, and trace the flow retrograde to learn what sort of data a particular statistical test is appropriate for.

Another way to learn more about statistics is to take a course at a local college or university. In addition, when reading the research literature in journals such as *Logistics Spectrum* and *Air Force Journal of Logistics,* researchers should pay attention to the statistical analyses used. Logistics educators should certainly review statistical principles with their students and require them to read logistics research articles.

In summary, when conducting logistics research, logisticians clearly need a knowledge of statistical analysis. Those not doing research, but who read the research literature (a good habit for all logisticians to acquire), also need a knowledge of statistics. Who needs statistics? All logisticians do!

Notes

[1]Campbell, S. K. *Flaws and Fallacies in Statistical Thinking*. Englewood Cliffs, NJ: Prentice-Hall Inc, 1974.

[2]Riegelman, R. K. *Studying a Study and Testing a Test*. Boston: Little, Brown & Co, 1981.

LOGISTICS WARRIORS

RABBIT FROM A MECHANIC'S HAT—WW II

The job of aircraft repair in combat theaters is impressive enough even when played straight. It becomes super-impressive when the boys begin, in the event parts and tools are absent, to ad lib substitute equipment—a flexible wrench, for example, that reaches around corners, or a passable pottage of *ersatz* dope (fluid for sealing aircraft fabric) from broken pieces of plexiglas dissolved in acetone.

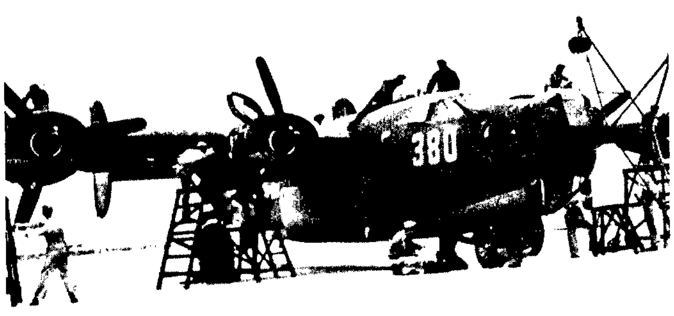
A classic example is the accomplishment of Tech Sergeant Otie P. Smith, of Powell Station, Tennessee, the head of the electrical shop in a service group in India. As if afflicted with an epidemic, four Liberators came into the service center suffering from bad trouble in the generator cannon plugs, small electric connectors like those plugged into a household wall socket, only with many more contact points and conducting wires. Whether it was the climate, the wear and tear and bumps, or something wrong with the product, the composition-rubber plugs had cracked and broken, permitting the current to arc and causing short circuits and fires. There were no replacement plugs in stock at the center, and even if there were, no one wanted to use them.

"He viewed a plane grounded because of failure in his department as a personal dishonor."

For the small Tenth Air Force a situation which kept four bombers out of action was of the utmost seriousness. So was it also for Sergeant Smith; he viewed a plane grounded because of failure in his department as a personal dishonor. Utterly dejected after a day of futile work on the problem he was walking back to his tent with an assistant when he gazed, at first absently and then transfixed, at one of the innumerable Indian bullock carts, pulled by the usual brace of black water buffaloes that plied the road past the camp.

" 'S matter?" asked Smith's partner. "You'd think you never saw one of those stinking cows before."

"By God, I got it!" Smith howled, and hit out instantly for the Indian city near the base. He returned an hour later, brandishing a pair of the long black curving buffalo horns, purchased for approximately 33 cents, American. He descended on the machine shop, slapped a horn in the lathe and turned it to the cylindrical shape and size of the missing plugs. What he was seeking was a substance that could be machined, that would not crack or break, that would withstand terrific heat and that would not conduct electricity.



He attacked the horn first with an acetylene torch and found it would not even singe. He gave it a jolt of 220 volts and got nothing out the other end on the voltmeter. He mauled it with a hammer and found it held up. He drilled the series of holes for the electrical points and ended with a perfect substitute, better, in fact, than the original product.

Smith subsequently was flooded with orders for his invention from airbases all over the China-Burma-India theater. No one could have been happier about the whole job than the Indians, who beat a path to Smith's shop peddling horns at a rupee a throw.

Captain Alfred Friendly, *The Guys on the Ground,* 1944

THE MUSHROOM EFFECT: VIETNAM

To the logistician, it is extremely important to have an early decision establishing theater standards of living. These standards should determine the basic authorization for post, camp, and station property, PX stockage of merchandise, whether base camps are to be constructed, construction standards, the degree of permanency for fixed installations, and utilities and services to be provided. Obviously, such a decision has a tremendous impact on the logistic system. Construction materials alone constituted some 40 percent of total tonnage of materials coming into South Vietnam in 1965 and 1966.

Without such established standards to use as terms of reference, it was impossible to realistically determine requirements for such items as real estate, supply, storage, maintenance, construction, electricity and other utilities, as well as the resultant port unloading capability required. Without such standards, the logistic system has no grounds for challenging requirements placed upon it. Such a decision was never made in the early days of Vietnam. Therefore, every unit independently established its own standard of living, ordering from supply catalogs as if they were Sears and Roebuck catalogs. Commanders desiring to give their personnel the very highest possible levels of comfort and quality of food, requisitioned air conditioning and refrigeration equipment far in excess of that authorized by Tables of Organization and Equipment. This had a mushrooming effect. Requirements for electrical power generating equipment were in turn increased to the point that demand exceeded the capability of Tables of Organization and Equipment authorized equipment. As the requirement for this equipment increased, the numbers of makes and models proliferated (as suppliers of standard makes and models were unable to keep up with the rapidly increasing demands). As the quantities of equipment increased, so did the requirements for repair parts and qualified maintenance personnel. The repair parts were a problem because of the many varied makes and models and the resultant lack of interchangeability among their parts. It was difficult to maintain full Tables of Organization and Equipment authorized maintenance strength much less the numbers of personnel required to maintain the excess equipment. Therefore, because these personnel were not readily available in sufficient quantities, back-up equipment was requisitioned (for emergency use) further burdening an already heavily taxed logistic system. Finally decisions were made on a piece-meal basis on such things as construction standards. But even with established standards, there was flexibility in interpretation.

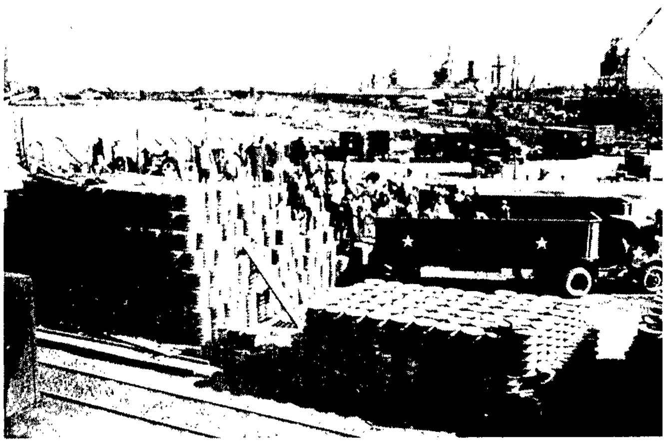
More often than not, the interpretation did not favor the most austere construction or equipment requirements. This not only put a heavy burden on the logistical system, but it also taxed the Continental U.S. troop base which was not structured in numbers or skills to support the construction or equipment installation and subsequent maintenance requirements which evolved from the Vietnam buildup.

From: *Logistics Support* by Lt Gen Joseph M. Heiser, Jr.

AN UNEXPECTED RELATIONSHIP

How do you determine gasoline requirements for combat and support forces in a theatre of operation.

Obviously, you have usage rates of gasoline for various types of vehicles. Obviously, too, you have the statistics on the expected



number of each type of vehicle in the theatre. However, now comes the rub— how do you calculate the rate of use (i.e., miles or hours) for these vehicles under combat and combat support conditions? There is no good method for forecasting this kind of vehicle use. The result is gasoline supply which either floods the market with unused fuel because figures are too high or a distribution which constrains and restricts vehicle use because the figures are too low. If you figure too high, and add the usual "fudge" factor, you tie up bulk shipping tonnage capacity which might be sorely needed elsewhere because you are shipping more than required. Of course, it goes without saying, if you figure too low, you may cause the loss of a battle or campaign or restrict our forces from their pursuit of the enemy.

This condition existed in World War II—the war of mechanized mass. All the efforts to calculate requirements for gasoline in theatres of operation were unsatisfactory until someone found an usual relationship which served to solve the problem. The relationship? There was a fine connection between *manpower* and fuel consumption. In all terrains, in all theatres, in all kinds of use, there was a general relation between the number of people and the gallons of gasoline required. That relationship was one gallon per man per day! Other POL products, such as grease, motor oil, and diesel fuel, had a fairly firm relationship with the number of gallons of gasoline; so the distribution problem was solved using these relationships and not worrying about hours or miles of use.

Jerome G. Peppers, *Personal Notes*

COMPLACENCY, SURPRISE, AND "LOW TECH"

Our own national experience underscores the dangers of underestimating the enemy's capacity for technological surprise. If one goes back to the aviation literature appearing in the United States during the years prior to Pearl Harbor, one is immediately struck by the dearth of items on Japanese military aircraft. The few deigning to discuss the subject do so with ill-concealed contempt. A writer in *Aviation,* then certainly one of the leading journals in the field, assured readers that "American aviation circles don't have to take a second look at the leading Japanese military aircraft types to decide that most of them are obsolete or obsolescent." Japanese air power, he declared, was not only obsolescent but "numerically meager" as well as "qualitatively inferior."

Complacency regarding Japanese technology was not confined to journalists with limited access to information. Captain W.D. Puleston, US Navy, one-time head of Naval Intelligence, was no less emphatic in reassuring his fellow countrymen in 1941 that American aviation was superior to Japanese aviation "in every branch." Not only did he find American aircraft faster, more maneuverable, and more up-to-date, incorporating the latest improvements developed as a result of the war in Europe, but he also insisted that "American personnel have more aptitude for flying" than their Japanese opposite numbers. Compounding the folly of these unsupported assertions was the endorsement of retired Fleet Admiral H.E. Yarnell, who declared that Puleston was "thoroughly qualified to deal with this subject."

What complacent Americans did not know was that the Japanese had been at pains to conceal their first-string aircraft from foreign eyes. At a time when writers in the United States were boasting that the antiquated Brewster Buffalo, the Navy's F2A, was "the most powerful fighter plane in the Orient," they were completely unaware of the existence of the Mitsubishi Zero. Events following the disaster at Pearl Harbor provided a rude awakening and a painfully abrupt rise in respect for Japanese technology.

We now know that, at a time when the fighters being produced in quantity in the United States had a combat range of 175 miles, Japanese fighters already were escorting their bombers all the way to Chunking, the Chinese wartime capital, and back, a distance of over 1,000 miles. They accomplished this feat, as we now know, with the use of drop tanks.

The idea of using supplemental fuel tanks to extend the range of combat aircraft was not new. Such range extenders were used successfully in World War I to stretch the legs of fighters escorting bombers on deep penetration raids. Indeed, in 1922, Major Carl Spaatz, as commander of the 1st Pursuit Group, asserted that fighter aircraft required a range equal to that of bombers in order to provide suitable escorts. The Air Corps Tactical School text on pursuit aircraft in 1929 mentioned the need to develop drop tanks to provide fighters with a 600-mile range.

With the spectacular development of *monocoque* bomber aircraft in the 1930s, however, the bomber replaced pursuit as the favored child of the Air Corps. As the speed and range of bombers increased, there was less talk of escort fighters. By 1939, an Air Corps study, based on *opinions* gathered by means of questionnaires distributed to operational units, declared "there appears to be little, if any, possibility of ever building an accompanying fighter with an operating range comparable to that of bombardment."

Not everyone in the Air Corps shared this doleful vision. At least one officer, a Captain W.G. Bryte, Jr., while a student at the Air Corps Tactical School in 1939, not only urged the development of long-range fighters to serve as bomber escorts, but he suggested that fighter and bomber units should lose no time in perfecting suitable escort tactics. He advocated an immediate procurement program to acquire drop tanks before the outbreak of war.

"A delay in producing a relatively simple piece of ancillary equipment threatened to negate the very concept of precision daylight bombardment."

In February 1939 the Curtiss-Wright Corporation, at that time the leading producer of fighter aircraft in the United States, proposed to develop a droppable fuel tank to extend range. This idea worked its way up the bureaucratic ladder, collecting endorsements for and against, but finally was squelched emphatically in May of 1939 with a decision signed by the Chief of the Air Corps himself: "No tactical airplane will be equipped with droppable auxiliary fuel tanks." That message brought all activity on drop tanks to a halt for two years—

two irretrievable years as it turned out. Fear of fire in the event of a landing gear failure was one factor in the Chief's decision. But the conviction that bombers would not require fighter escorts may well have been the real reason for the negative decision.

That faulty decision was to prove enormously costly in lives lost and in delays in demonstrating that daylight strategic bombers could successfully penetrate the enemy heartland and cripple his economy at vital nodal points. Although drop tanks used by P-38 fighters in North Africa clearly had demonstrated their effectiveness in 1942, the P-47s that made up the fighter complement of the 8th Air Force in the British Isles in early 1943 were still arriving without external tanks. Their internal fuel supply still limited them to a combat radius of 175 miles. As a consequence, when the first Schweinfurt raid was launched, 17 August 1943, escort fighters could not accompany the raid more than a part of the way. The result: 60 bombers shot down, a 33 percent loss; worse yet, 600 trained crewmen struck from the rolls.

As every student of air power knows, the 8th Air Force finally did get its drop tanks—by the tens of thousands—and by the summer of 1944 the P-47 could go a thousand miles, all the way to Berlin and back with fuel to spare for dog-fighting. For us, however, the point of interest is that a delay in producing a relatively *simple* piece of ancillary equipment threatened to negate the very concept of precision daylight bombardment, the premise on which the whole prevailing air power strategy rested.

". . . we would be well advised not to overlook strategic implications of the more mundane technology. . . ."

The realization that relatively *low* technology can, and often does, have a profound impact on strategy should arrest our attention. Public discourse on the relationship of technology and strategy—whether carried on by publicists, military professionals, or academic scholars—tends to focus on high technology, The Bomb, or The Bomber, be it the B-17 of World War II or the B-1 of a generation later. But the story of the drop tank suggests we would be well advised not to overlook strategic implications of the more mundane technology and its capacity for providing that leverage of surprise which can tip the strategic scales.

Dr. I.B. Holley in Margiotta and Sanders, *Technology, Strategy and National Security.*

INTERDICTING NORTH VIETNAMESE LOGISTICS

The complex political factors and the equally complex command organization in Vietnam led to many misconceptions about the interdiction campaign. Some observers viewed the campaign as four separate but somewhat interrelated operations—the bombing campaign in North Vietnam, the interdiction of the Ho Chi Minh Trail in southern Laos, the attacks against the LOCs in northeastern Laos, and the attacks against the roads and trails in South Vietnam. We had, however, only one interdiction campaign and it embraced *all* these areas. We used different rules of engagement and different tactics in each area, but all of the parts made up the total campaign. Because of the confusion about the totality of the campaign, few observers appreciate how each element of the campaign had an effect on the others.

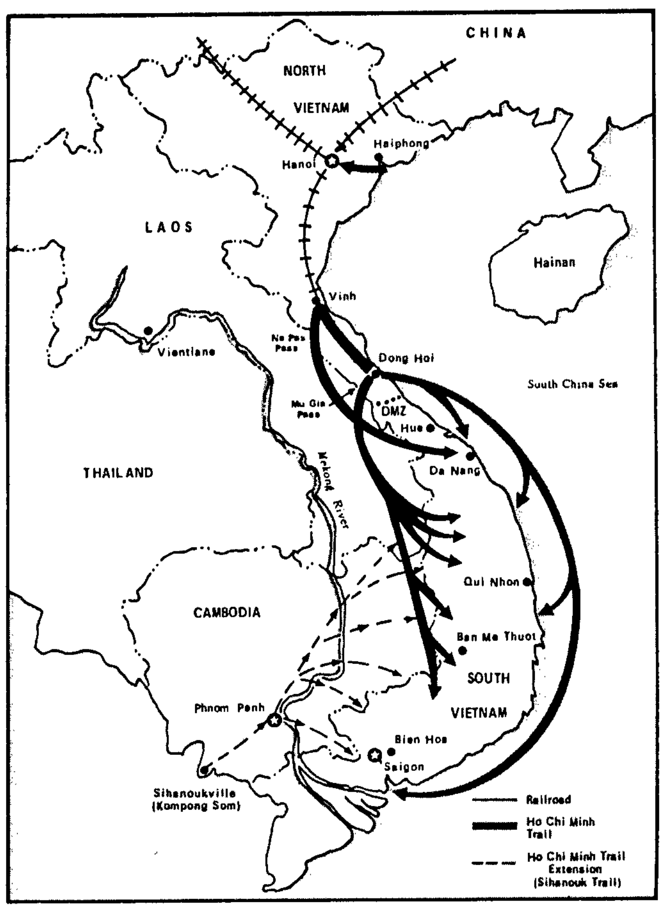
". . . less sophisticated forms of transportation reduced further their vulnerability to air attack."

The campaign, to be effective, had to begin with attacks on the *head* of the system in North Vietnam. At that point the lines of communications were most vulnerable to an attack, and there the supplies and repair and support facilities for the entire logistics system were located. Sortie for sortie, there the most devastating attrition on supplies could be achieved, and there the most vulnerable bottlenecks were located. Interruptions in the flow at those points would create a greater delay and disruption of materiel moving through the rest of the network. Approximately 30% of the important transportation targets were in Route Packages IV, V, and VI. If we were significantly to reduce the logistics flowing to the North Vietnamese and Viet Cong in the south, we had to deal that part of the system, with its high density of critical items, the most damaging blow.

"Failure to stop the supply flow at the head of the system (in North Vietnam) made it most difficult to pinch off supplies for the enemy's army in South Vietnam."

As the transportation system threaded its way south in North Vietnam, we found fewer vulnerable segments that could be blocked for any length of time. Furthermore, the nature of the terrain allowed the North Vietnamese to relieve backed up traffic with by-pass routes. In the southern part of the system, traffic dispersed and moved in such small segments that we could not achieve a satisfactory destruction rate per attack. As the supplies moved closer to the battlefield in South Vietnam, less sophisticated forms of transportation reduced further their vulnerability to air attack. While freight trains of 40 or more cars transversed the northeast railroad leading from China to Hanoi in Route Package VI, supplies made their way across the DMZ in trucks; during 1966-1968, many supplies were delivered into South Vietnam on bicycles and by porters with "A" frames. The less vulnerable means of transporting supplies required intensive reconnaissance, even to locate the trails. It was yet more difficult to attack such movements at night.

Materiel moving through the system in southern Laos posed a different problem. The Hanoi delta and the LOCs along the coast to the DMZ were in open terrain. We could more readily detect movement and use air attacks to halt the flow in such areas. However, the roads in Laos were concealed in many places by triple canopy trees, which, along with clever camouflage, helped hide truck



movements. When attacked, trucks moved off the road into the surrounding jungle. Because of the jungle cover, successful interdiction in Laos was extremely difficult. Hence, failure to stop the supply flow at the head of the system (in North Vietnam) made it most difficult to pinch off supplies for the enemy's army in South Vietnam. Unlike other parts of the transportation system, the South Vietnamese section used no major road systems. From 1965 to 1972 most of the materiel was moved by porters and some limited number of vehicles. (However, in the 1972 Easter offensive, the enemy used well-developed roads built during the bombing halt to support forces in Military Regions (MR) I, II, and III.) By the time the logistics had moved into base areas within South Vietnam, interdiction was not a productive effort.

Because of the relationship of the parts of the LOCs, the place to put pressure on the system was in the heart of North Vietnam. Blockading or bombing the ports was essential for a decisive campaign. Without eliminating the ports where the bulk items entered, reducing the flow to South Vietnam was again made more difficult.

Even without eliminating the ports, the interdiction campaign was able to limit the number of forces the North Vietnamese could support in the south. Not until the interdiction campaign ended with the termination of U.S. involvement could the North Vietnamese logistically support and deploy their full strength of 18 to 20 divisions. Before the 1975 offensive, they never deployed more than 11 or 12 divisions, apparently for fear of the destruction they would suffer by exposure to our airpower. A similar thing happened in the Korean War when the Chinese Communist Army was stalemated with more than 1,000,000 reserve troops who could have been thrust into the battle to break the stalemate. The destructive toll of the 5th Air Force interdiction campaign probably led to the decision by Chinese leaders that UNC airpower would make it unfeasible to sustain such a deployment without air superiority. There was no evidence that the Chinese lacked Russian support for deployment of larger ground forces. Nor was there any evidence that the North Vietnamese lacked Russian support if they had elected to deploy another 100,000 troops.

General William W. Momyer, *Airpower in Three Wars*

LOGISTICS AS STRATEGY IN THE MED

Logistics becomes strategy when offensive planning is being accomplished. After all, there is no real goal for attack other than to destroy the enemy's military capability. What produces military capability? Logistics! Therefore, the tactics and the strategy of attack are directed to eliminating the logistics strength of the enemy and, therefore, logistics of the one side becomes strategy for the other side.

Early in 1944, the Allies were fighting a tough and very experienced German army in Italy under Field Marshal Kesselring. The going was rough because the Germans were excellent fighters and the mountains made attack difficult. General Jacob Devers, who headed all American field forces (including the Air Force) in Italy and North Africa, decided to destroy Kesselring's logistics support. The Allies knew Kesselring required about 4,000 tons of supplies a day to support his eighteen divisions when not in battle and 5,000 tons a day when being attacked or on the offensive.

"Logistics of the one side becomes strategy for the other side."

Supplies came south to Kesselring via rail, road, and coastal shipping from Northern Italy and Germany. The 12th Air Force, the Tactical Air Force of the Med, attacked the logistics chain with all available aircraft. The 15th Air Force, the Strategic Air Force of the Med, participated by bombing German airfields and port facilities. Rail lines were cut in as many places as possible. More importantly, bridges were destroyed, tunnels were blocked, and viaducts were collapsed, thus making repairs more difficult and time consuming. As the Germans hurried to rebuild or repair these damaged necessities, the Allied air re-visited and again destroyed them. Ships along the coastal waters were sunk and ports effectively closed. There was practically no air opposition because the 12th destroyed airfields and aircraft. It came down to truck supply as the only available transport for essential materiel. Drivers often refused to operate in daylight because that meant certain strafing and probable injury or death. The main roads were closely patrolled by 12th tactical fighters, so trucks had to use the bad secondary roads which slowed traffic and delayed support. Only a small quantity of needed war materials got through to the eighteen German divisions.

When General Devers began his assault on May 11, the forces of Kesselring were in dire straits. They did not have the logistics support they needed for effective resistance. The line collapsed and the Allies took Rome. The end of the German hold on Italy was closer because logistics had become strategy.

Jerome G. Peppers, *Personal Notes*

Most Significant Article Award

The Editorial Advisory Board has selected "The Doctrinal Challenge: A Rebirth of Logistics Thought" by Lieutenant Colonel William T. McDaniel, Jr., USAF, as the most significant article in the Winter issue of the *Air Force Journal of Logistics*.

Most Significant Article Award for 1985

The Editorial Advisory Board has selected "Avionics Reliability—The War We Are Winning" by Jerry D. Schmidt as the most significant article published in the *Air Force Journal of Logistics* during 1985.

"Book or no book, the men go out into the combat zone as experts. And as something more, for added to their skill is a definition-resisting but strictly American synthesis of skepticism, inventiveness and doggedness. If holders of the peacetime faith condemn as heresy the notion that anything other than a rubber tire can be put to an airplane wheel rim, these guys have nonetheless tried—and succeeded in—substituting a coil of Chinese peasant-made rope. They are pragmatists, and because they held their high-school jalopies together with nails and chewing gum, they do the same with airplanes and count it good because it works. If a factory manager would scream at the thriftless idea of ten men spending three months rescuing a wrecked plane, a bomber commander whose hitting power is thereby, and only thereby, increased by ten percent does not quibble about cost accounting. They are resourceful and they are determined. When a gasoline dump takes fire, the mere expert's way of extinguishing it, if at all, is not to drive into it with a bulldozer-scraper, shoving dirt on the flames. But if a bulldozer-scraper is the only equipment you have on a North African airfield and a sergeant with a lot of guts puts out the fire and saves 5000 gallons—well, there are other values besides orthodoxy."

Captain Alfred Friendly
The Guys on the Ground, 1944

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